POWER

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Courtesy to Salesmen

ON one of the trips that I used to make I called upon one of our friends and spent part of the forenoon visiting with him and looking over his plant.

When I sent in my card a man with a sample case sat in the waiting room. When we came out at noon, on our way to the club, he was still sitting there. My host, whom he had come to see, passed him without notice. He was just a salesman.

It was he who was looking for something. The buyer had the whip hand. Let him wait!

It would have taken only a few minutes of the big man's time to dispose of him or to defer the interview and leave him free for other calls; and a few words of kindly attention would have meant so much to the salesman, his feeling toward the prospect and for his calling.

The proprietor did not have to go out and solicit as a favor an opportunity to display his wares and explain their advantages; but I wondered how he would regard the ignoble treatment of his own salesmen by others that, I learned, he habitually accorded those who sought his patronage.

I wondered if he never found himself in the position of one who sought consideration; a contract which needed some indulgence in its enforcement or interpretation, an occasion where financial accommodation was desired.

How would he feel if a buyer with a grievance, or his banker, let him wait for half a day in the cooler for a chance to discuss an adjustment or an extension of credit?

Contumely toward those in dependent positions adds nothing to the standing of those in authority. Treatment which rebuffs and demeans the status of the seller's representative is likely not only to deprive the possible purchaser of pertinent and helpful information, but to be retributive as regards himself and his own selling force.

F. R. Low

EDITORIALS

Superpower Economics

INTERCONNECTION between generating stations of a specific system and the linking of one system to another has progressed to such a degree that great networks of distribution lines may be served by a chain of large, economical stations located at strategic points. The movement has not been limited to any one section of the country. Water powers are joined with steam stations located near the coal mines or, where such a site is not available, adjacent to a better water supply than is obtainable near the center of the load.

Continued growth of these great systems indicates that the plan possesses economic valve. It has been definitely proved that large stations and large units may be more economical than small ones. Commercial efficiency permits a greater degree of refinement. Labor is less per unit of output. First costs are reduced; in outlying locations land is cheap and building costs and taxes are lower. Coal delivery is simplified and more reliable, because the congestion of freight terminals in a large city may be avoided. The haul may be short, so the largest item in the fuel cost will be greatly reduced.

Reserve power in any one station is potentially available to all other stations, therefore the stability and reliability of the energy supply may be assured with less reserve capacity. It is possible to use the most economical stations and obtain the maximum benefit from connected water power. The trend toward higher voltages is reducing the cost and the losses of transmission.

In short, the foregoing briefly expresses the advantages that have been attributed to interconnection. The future offers something more. Bringing low-cost energy from efficient stations to many small communities along the lines will be an advantage of growing importance. Large industries may prefer these localities to metropolitan areas, and, to reduce transmission costs to a minimum, might find it advantageous to reverse usual procedure, in which the current is carried to the consumer, by locating immediately adjacent to one of these large power stations.

Even then the possibilities of such a move are not exhausted. If it proved economically desirable to supply these industries with steam for process, as well a practice that should be readily feasible within limited distances from the station, the advantages would be mutual. The great loss of heat in the condenser cooling water would be eliminated. Where an approximate balance could be obtained between power and process steam, the heat utilization, or thermal efficiency, would be more than doubled, and as one service would be a byproduct of the other, commensurate rates could be made that in many cases would prove attractive to the consumer.

World Power

LAST WEEK Prof. Albert Einstein, Germany's most distinguished scientist, sent his greetings to the delegates to the Second World Power Conference in Berlin, which opens as this number of *Power* goes to press.

"It is sure," said the scientist to the engineers, "that the great thought of international political organization of our planet, through the development of technical science, has stepped from the sphere of distant speculation into that of reality. International thought, in turn, fructifies technique. Thus we see in the World Power Conference a promising manifestation of the cultural, economic, and political co-operation of the nations."

Actually the facts warrant an even stronger statement. The World Power Conference is more than a promising manifestation of the cultural, economic, and political co-operation of the nations—it is an example of co-operation that shines by contrast with the still feeble and halting efforts in many other fields. The suspicions and horse-trading instincts that still play freely about conferences dealing with trade and disarmament are cast aside when the world's engineers come together to discuss their technical problems.

America will contribute to the conference particularly by revealing her experience with systems, plants, and individual units of outstanding size. Nowhere else has

power such magnificent dimensions. But the exchange will not be one-sided. Engineers of other countries, particularly Germany, have approached power problems with competent minds and virile imaginations. Their striking originality in developing new types of boilers, prime movers, and similar equipment, and in arranging these in new combinations, will not be wasted on the American delegates.

Significantly, the keynote of the conference is economic. Power technique will be discussed in all of its phases; but the dollar, pound sterling, mark, and franc will be always in the foreground. This economic emphasis means simply that the conference is to be practical rather than academic. Its papers and discussions will be of direct interest to American engineers engaged in the task of manipulating energy in a machine age.

Power will be there in the person of its editor, Ely C. Hutchinson, who goes also as an official representative of the United States Government. His cabled reports will bring to the readers of this publication a first-hand impression of the conference and a summary of its high spots.

Condenser and Cooling Tower for Building Plants

WHEN byproduct power is generated from steam used for building heating there is a period of about five months during which the engine or turbines exhaust to the atmosphere. This operation is wasteful of fuel and requires nearly one hundred per cent make-up for the boilers, an item of some magnitude when water is purchased.

The possibility of installing condensing equipment and a cooling tower appears to be generally overlooked. It may be argued that the added expense for this equipment cannot be justified by the savings. Under some circumstances this undoubtedly is true, but many more installations of this character could be economically installed than has been the case.

During the winter a steam engine exhausting to the heating system can be expected to produce a kilowatt-hour for, say, four pounds of coal. Condensing operation might cut this fuel consumption in half. Thus in the five months that the heating system is shut down an office building using 30,000 kw.-hr. a month would save about $1,000. At 15 per cent this saving would justify an investment of $6,600 in condensing and cooling tower equipment.

An office building using 30,000 kw.-hr. a month would require a cooling tower and condensing equipment capable of handling the exhaust from an engine of about 250 kw. capacity, which could probably be provided for slightly less than the $6,600, the exact amount depending on conditions. Even with a capacity factor as low as that assumed here, the savings are sufficient to warrant consideration being given to the installation of condensers for summer operation.

The Cold Water Test on Boilers

THE following comments from a correspondent are presented on the editorial page to direct attention to a matter of considerable practical importance. Comments of *Power* readers are solicited.

"In many places it is still the practice of boiler inspectors, and even power-plant operators, at the time of inspection to give a boiler a cold-water pressure test. The test pressure is generally one hundred and fifty per cent of normal.

"When boiler pressures were low and the sheets forming the boiler were not over five-eighths of an inch thick, this test was not unduly severe, particularly since boiler operating temperatures were also low and joints did not take permanent sets.

"The case is different with modern boilers, especially those which operate at three hundred pounds pressure and above. Butt joints with inside and outside cover plates are the rule, and these are generally calked on the inside. Operating temperatures are relatively high, and the whole boiler drum deforms slightly under service conditions.

"When a cold water test is applied at one hundred and fifty per cent of the working pressure and at the low temperature of the cold water, the shell and joints are deformed beyond, and differently from, the normal working limits. Undue stresses are thrown on the calked edges, which frequently slip slightly. Later when the boiler is put under steam these calked joints commence leaking and the boiler must be removed from service for recalking. After a few such tests it is nearly impossible to keep some joints from leaking.

"If permissible, these might be closed by welding, but this is generally discouraged. Operating engineers consider this cold-water test too severe on modern boilers. Some use cold water up to full working pressure. This appears to be satisfactory as an indicator of leaky tubes or joints. If the cold-water test at fifty per cent over pressure is unduly severe, and, furthermore, unnecessary to detect leaks, it should be superseded by a more rational test. A free discussion of this subject will develop the facts on which changes may be advocated in the boiler code."

▼

POWER *Stands for . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**
8. **Prevention of Smoke, Within Reason**

▼

NEW ANHEUSER-BUSCH PLANT

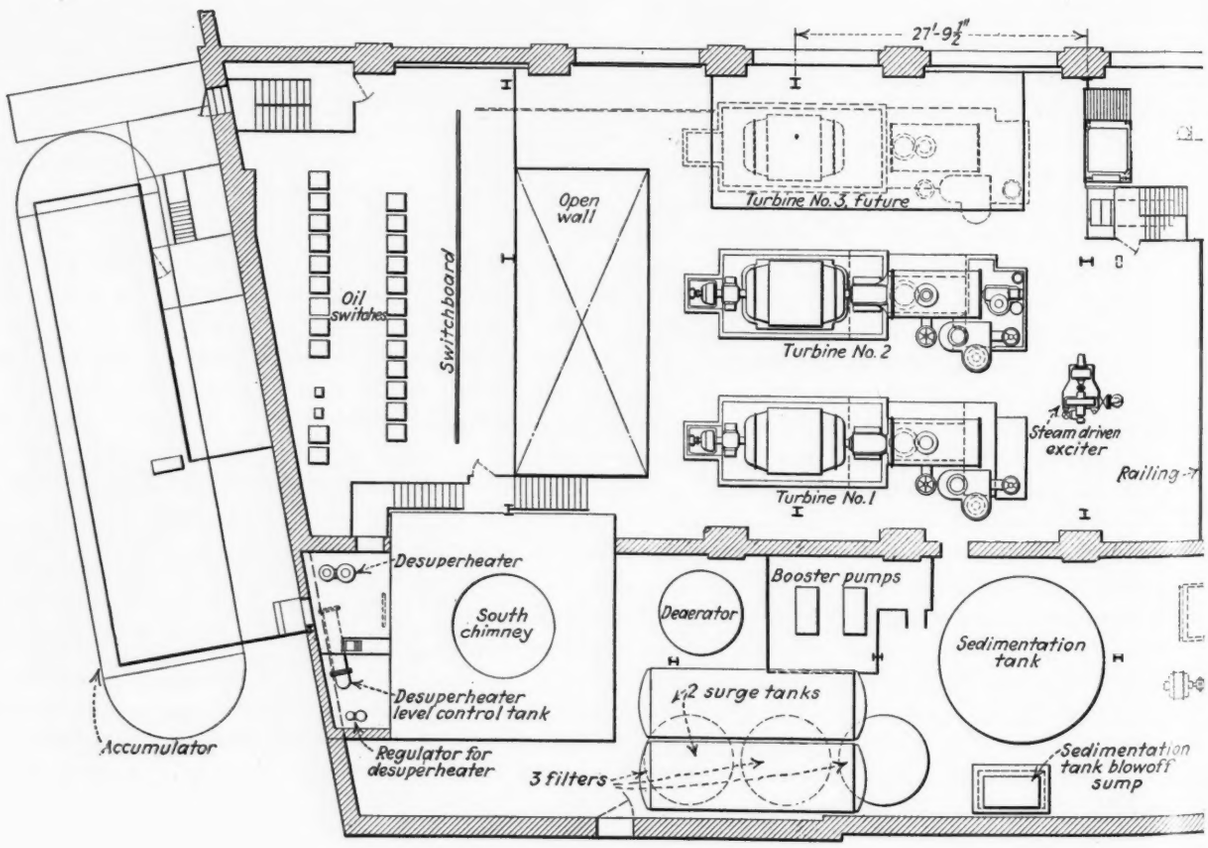
Designed for Efficient and Reliable Operation

New centralized 7,500-kva. plant installed in old boiler house operates at 500 lb. pressure. Boilers (10,760 sq.ft.) are provided with water walls and air heaters and are fired by pulverized-coal unit system. Turbines bleed to process. Water conditioning, automatic combustion control, and continuous blowdown are other features of interest

By VICTOR LIPTON
Ophuls & Hill, Inc., Consulting Engineers

WHEN the Eighteenth Amendment became a law, Anheuser-Busch, Inc., of St. Louis, Mo., owned a gigantic brewing plant that covered approximately 100 acres of ground. Practically all of the equipment of this plant was devoted to the manufacture of beer. It is a notable achievement that in a relatively small number of years the company was able to find other uses for its plant, by the development of manufacturing processes kindred to the brewing industry, which has placed this business again on a profit-earning basis.

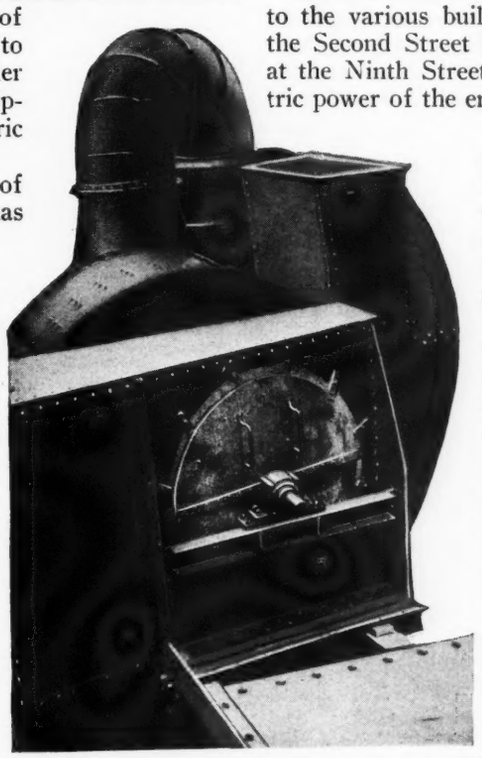
The business conducted by Anheuser-Busch, Inc., before Prohibition, growing as it did by leaps and bounds, covered with its buildings and equipment a vast territory. These were served by two boiler plants and three engine rooms. Renting to other industries the outlying buildings not needed for its new manufacturing processes, the management concentrated its own manufacturing proc-



esses in a relatively restricted area. It then became apparent that the use of the existing boiler and engine plants made the production of steam and electric power unduly expensive. Moreover, the electric current required for the new manufacturing processes increased beyond the generating capacity, so that current had to be purchased from the Union Electric Light & Power Company. In addition to this, it was seen that the steam generating equipment of the two boiler plants would soon be inadequate.

For this reason the management decided to investigate the cost and savings to be obtained from the installation of a modern power plant. As a result of this investigation it was decided to use the present Ninth Street boiler house, installing the necessary equipment to furnish all steam and electric power.

A manufacturing establishment of this kind, the growth of which has extended over several generations, naturally contains a rather complex assortment of steam and electric power apparatus.



Induced draft fan on boiler No. 1

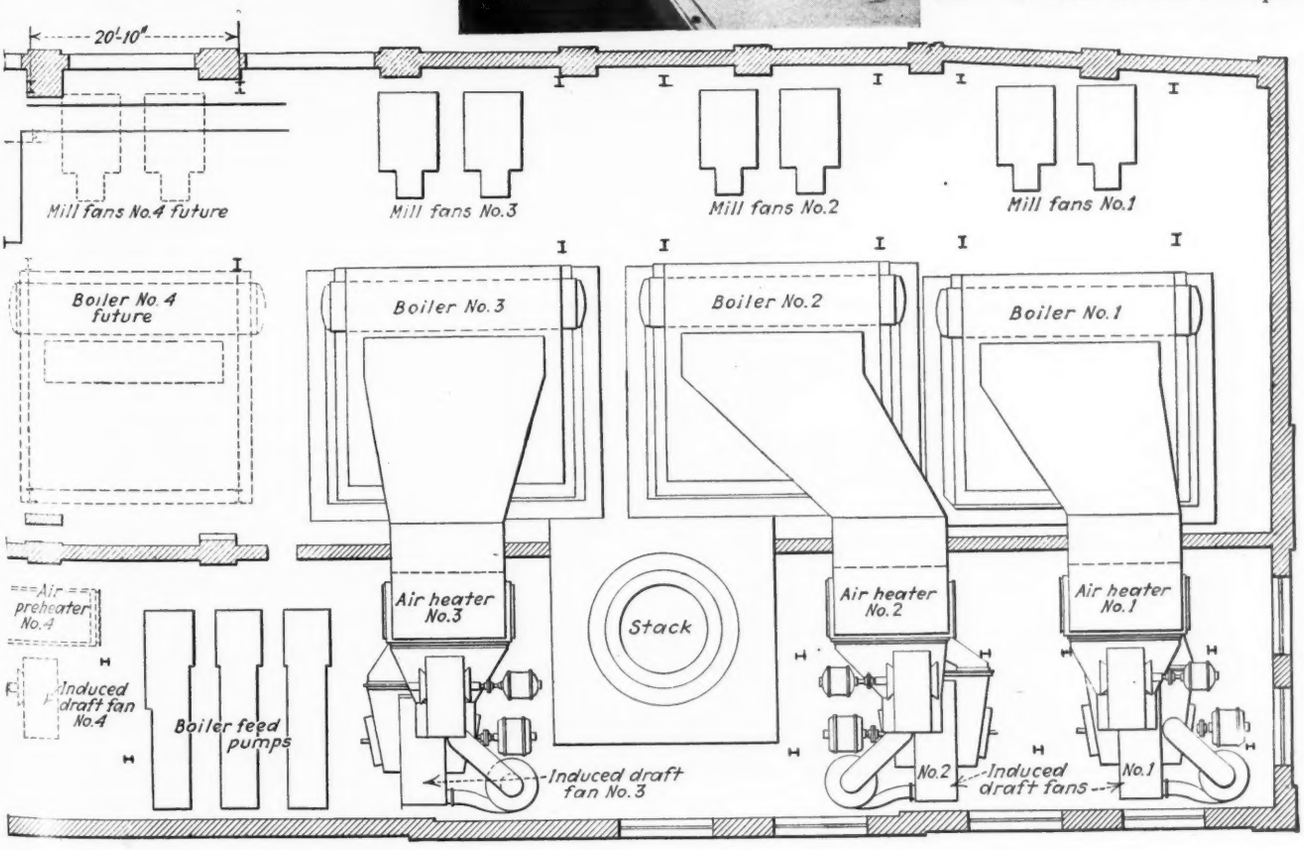
Plan of new plant showing the 10,760-sq.ft. pulverized coal fired boilers and 3,750-kva. turbines

When construction was started on the new boiler and power plant in December, 1928, there existed two old boiler plants, one at Second Street with eleven Heine boilers fired by chain-grate stokers, and the other at Ninth Street with fourteen similar units. In addition there were three engine rooms. At Second Street were two compound vertical Fulton engines, each operating a 500-kw. generator. Similar equipment was installed at the Ninth Street power plant. A third plant was equipped with Diesel engines capable of developing approximately 1,350 kilowatts.

Union Electric Light & Power service was distributed to the various buildings through a rotary converter at the Second Street power plant. A motor-generator set at the Ninth Street power plant supplemented the electric power of the engine-driven units.

Steam was produced at 150 lb. gage pressure. The various power units, refrigerating machines, pumps and other auxiliaries were operated at that pressure, and some of this high-pressure steam was used in the dry grains department, digesters, etc. By far the largest amount of steam used in process was distributed at 30 lb. and 5 lb. gage. The approximate quantities of steam distributed at these pressures are as follows: (*a*) 150-lb. steam for operating prime movers, 90,000 to 120,000 lb. per hour; (*b*) 30-lb. steam for process, 20,000 to 40,000 lb. per hour; (*c*) 5-lb. steam for process, 40,000 to 60,000 lb. per hour.

Exhaust from the various engines and from some of the refrigerating machines went to the 5-lb. steam system. A steam accumulator operating



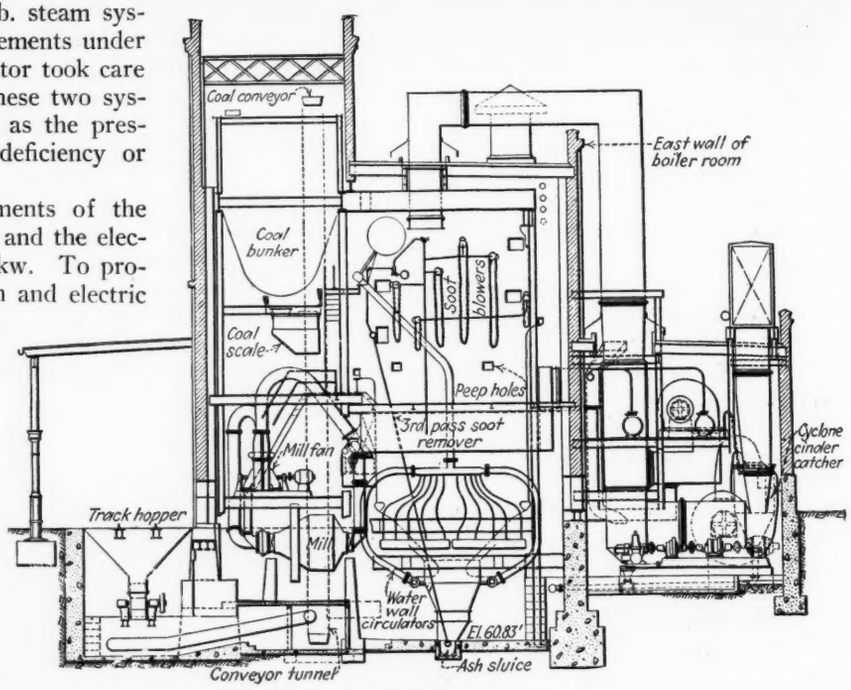
from the 150-lb. line supplied the 30-lb. steam system and some of the 5-lb. steam requirements under item *c*. At the same time the accumulator took care of the short peak steam demands of these two systems, the boiler output being adjusted as the pressure in the accumulator indicated a deficiency or excess of 150-lb. steam generation.

During 1927-28 the steam requirements of the plant had risen to 200,000 lb. per hour and the electric load had reached a peak of 2,500 kw. To provide for a reasonable increase in steam and electric power requirements of the plant it was decided to install a plant able to produce 275,000 lb. of steam per hour continuously. Actually, however, three units, each capable of generating 150,000 lb. of steam per hour, were installed. The present electric load is approximately 3,500 kw. The two steam turbines now maintained have a capacity of 3,750 kva. each, giving 7,500 kva. of new capacity.

All motorized equipment of the plant was of the direct-current type, but since the expansion program contemplated the installation of additional machinery requiring considerable power, it was decided to change over to alternating-current generation and furnish direct current to existing equipment from motor-generator sets.

The foregoing gives a brief outline of the machinery equipment in use and the steam and electric power requirements up to 1928, when it was decided to investigate the probable cost of building a power plant to furnish all steam and electric power for the whole manufacturing establishment and to estimate the potential saving in operating expense.

The installation cost and operating expense of five different designs were computed, including, in some, an entirely new power plant building, and, in others, remodeling the Ninth Street boiler house. Based on these figures, it was decided, as already indicated, to house the entire new equipment in the present Ninth Street boiler house. This is a substantial brick building with two good stacks and ample room for four 10,760-sq.ft. boilers and three 3,750-kva. turbines. It also, fortunately, is not far from the center of the steam and power loads.



Cross-section through boiler room

The next problem to solve was to choose between chain-grate or underfeed stokers, or pulverized coal firing. The company controls its own coal mines in the western part of Illinois. The low grade of coal available from these mines will be seen from the following ultimate analysis:

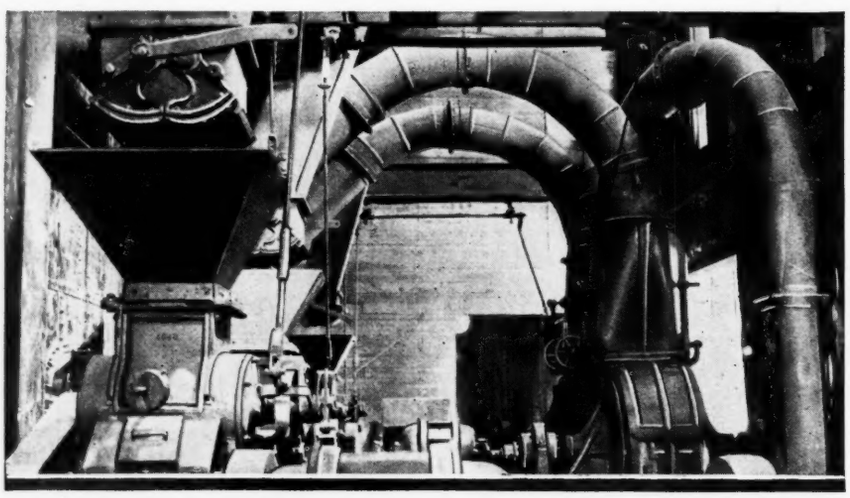
N = 1 per cent
C = 50 per cent
H = 4.6 per cent
O = 11.0 per cent
S = 4.0 per cent
Ash = 15.4 per cent
Superficial moisture = 14.0 per cent
Heating value as fired = approximately 9,500 to 10,500 B.t.u. per pound.
Ash fusion point = about 2,000 deg. F.

Where mechanical stokers are used with coal from this territory chain grates are generally selected.

Studies indicated that pulverized-coal firing would be most suitable, but data on experience in the pulverizing of the low grade Illinois coal to be used were not available. Several carloads of coal were therefore sent to an experimental pulverized-coal plant for tests. These showed that a proper fineness of pulverizing was possible, with a consequent satisfactory combustion condition.

The air-swept ball-type mill was chosen because of the high and fairly constant percentage of fines produced.

Furnaces were designed with all four walls water cooled, using 3-in. bare tubes on $3\frac{1}{2}$-in. centers, backed by a $2\frac{1}{2}$-in. refractory tile and insulation. The hopper bottom, running down at 45 deg. from the front and rear walls, was constructed of 3-in.



Transport pipe fans and feeders on boiler No. 2

tubes on 3-in. centers, covered with a layer of light refractory tile. About 98 per cent of the furnace wall surface is water cooled. Since load variations in one boiler will range from a minimum of 30,000 lb. per hour to a maximum of about 150,000 lb., thorough mixing of the air and fuel, as well as fine pulverizing, are necessary.

The bare-tube rear water wall requires, in turn, a short flame to avoid wall damage. A burner of the turbulent type was chosen as best suited to meet these requirements.

Three of the four projected 10,760-sq.ft. boilers and two of the three projected 3,750-kva. bleeder turbines are now installed. One boiler and one turbine will be spares. The remaining power demand is furnished by the two 500-kw. Fulton Diesel engine sets in the old Ninth Street engine room.

Utilization of the Ninth Street boiler house required some structural steel changes and excavation for a basement. These changes, however, cost much less than a completely new building, without considering the difficulty of finding suitable space for a new structure.

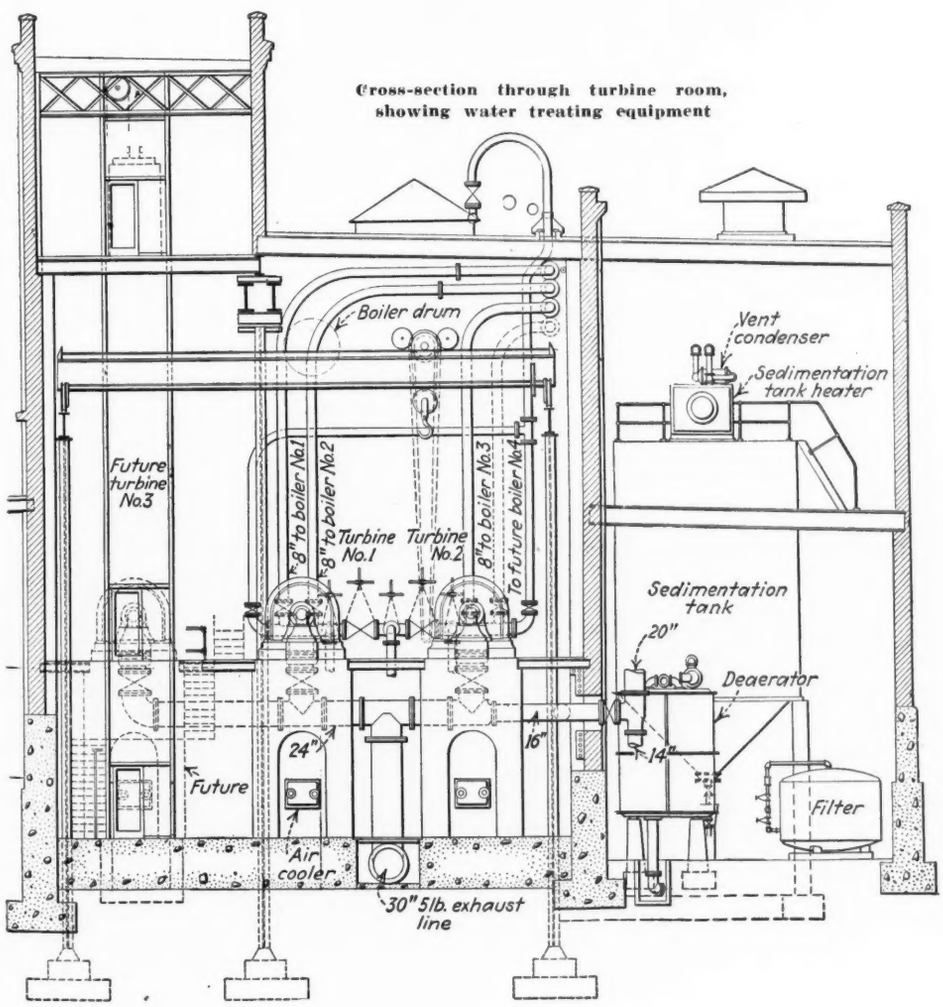
To start construction of the new system, four of the existing boilers with their auxiliaries, as well as most of the old boiler-feed pumps and feed-water heaters, were removed. Two of the three new units were set in their place.

The first step was the clearing out of all old feed-water apparatus that could be spared and the installation in its place of a modern water-treating system to permit higher ratings on the remaining old boilers during the change-over period. At the same time two new boilers, air preheaters, induced- and forced-draft fans, bleeder heaters, and related apparatus were installed.

A maximum of only 125 per cent of existing boiler rating could be carried with the available feed water. To maintain high ratings on the new boilers a completely new water-treating system was installed. This consists of a lime and soda ash sedimentation tank (hot process softener), pressure-type sand filters, and a deaërator, coupled with necessary chemical feed pumps and chemical mixing tanks. In order to do away with all scale deposit, the Hall system of conditioning was adopted. This required a mixing tank with chemical feed pump for the special sodium phosphate used. Complementary apparatus, such as vent condensers for preventing steam waste, was included. Booster pumps were installed to raise the water into the sedimentation tank water heater. Air agitation is used for filter wash, since with large filters an appreciable amount of water can thus be saved.

The original water treatment left the make-up water with about 11.5 grains of total solids, which the hot process will reduce to 1.5 grains. The make-up is approximately 70 per cent, 30 per cent being returned as condensate from various processes.

To insure effective blowdown without waste, and to have the operators fully conversant with what is going on, a continuous blowdown system was installed. Regulating valves and a blowdown meter are provided so that the operator, by simply setting the needle valve, is assured that he is blowing down sufficient water for a set rating or a known water condition. Samples of this blowdown are collected at given intervals for chemical analysis. The operator is advised of the nature of the water he receives from the water-treating system and can govern himself accordingly at the blowdown.



Cross-section through turbine room, showing water treating equipment

This continuous blowdown system involves a flash tank for receiving 460 deg. water and "flashing" it into 140 lb. steam. The remaining blowdown, at 361 deg., goes to the heat interchanger ahead of the hot-process softener and is cooled by the incoming make-up water. The blowdown, averaging about 6 per cent of the steam generated, is finally collected in a large sump and is used for ash sluicing.

The new boiler feed pumps temporarily supplied the old 140-lb. boilers. On this account, and also to keep the high-stage feed heater at moderate pressure, the pumps were built with two casings. The first casing has two stages and delivers at 225 lb. through a high-stage heater to the second casing, which is three-stage. This boosts the pressure to a 575 lb. maximum. These pumps have a capacity of 400 gal. per minute each and are turbine driven by 140-lb. steam, with provision for the addition

of electric motors. Exhaust from the turbine drive of the feed pumps is connected to the deaërator and to the heater sedimentation tank on the hot-process softener.

Two surge tanks parallel the deaërators for emergency purposes and receive the drip from the high-stage heaters to keep the water in them heated to 228 degrees.

Feed heating proceeds as follows: The blowdown exchanger, low-stage heater, and deaërator are kept at 218 deg. by 5-lb. steam. The high-stage closed heaters maintain a 350 deg. temperature by means of the 140-lb. steam supply. Clean condensate returning from process enters the deaërator direct at about 160 deg. All other condensate return not absolutely pure goes through the hot-process softener first and is then deaërated.

About 18,500 lb. per hour of the condensate from the high-stage heaters is cooled and taken out of the power plant for making ice, supplanting the present water supply from engine condensers. The condensate from the old engine condenser is oily and must be reboiled before use. This process is wasteful of heat. The new method will give pure water for ice making at lower cost.

In the event that the plant steam load is too low to supply enough drip for can water from the heaters, 5-lb. steam can be condensed from the main turbine exhaust to make up the deficit.

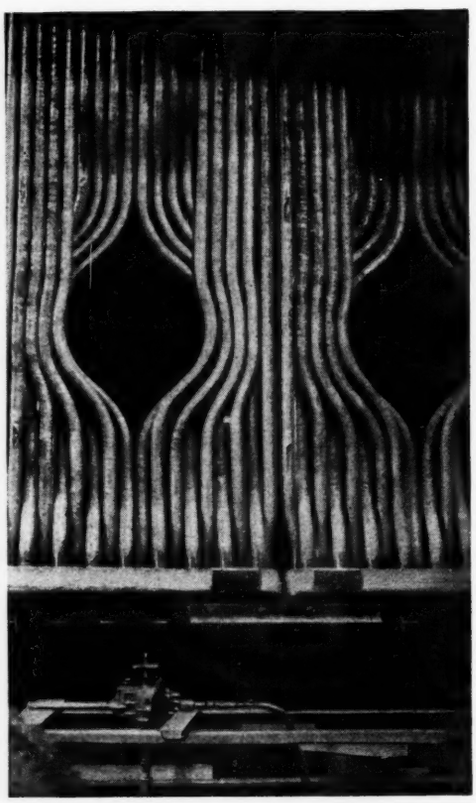
The boilers are 10,760-sq.ft., 54-in., cross-drum units, with 3-in. x 20-ft. tubes, for 506 lb. maximum working pressure. Convection superheaters of 2,220 sq.ft., installed at the top of the first pass, will raise the steam temperature to 600 deg.

The furnace and ash hopper are completely water cooled by 2,050 sq.ft. of 3-in. tubes. The 2½-in. refractory tile is placed behind the tubes, backed with 3 in. of insulation and a steel casing. With a furnace volume of 8,750 cu.ft. the maximum heat release is less than 20,000 B.t.u. per cubic foot per hour.

The main ash removal system consists of a high-velocity jet sluice. Each hopper is equipped with four rack-and-pinion gates discharging to ash tables, which are cleared by oscillating nozzles to regulate the feed to the main sluice below. The main sluice is horizontal, with a 4-in. step upstream of each boiler containing the kicker jets. The sluiceway is concrete, lined with hard-iron trough sections, and delivers straight to the main sump.

For clearing fly ash from the preheater hopper and cyclone dust collector a steam and water jet system removes ash continuously. Two motor-driven 1,000-gal. per minute pumps, operated when needed, supply water at 110 lb. for the main sluice. One 100-gal. per minute pump is operated continuously for the fly ash.

The main sump is 25 ft. below yard level. Two 1,000-gal.-per-minute float-operated vertical dredging pumps remove ash and water from the sump to the ash pit from which the ash is removed by a grab bucket.



Front water wall showing openings to receive burners

Each furnace is equipped with two burners set approximately 14½ ft. down from the first row of tubes and about 7 ft. 3 in. from the side walls. The burners have a maximum capacity of 8,770 lb. of powdered coal per hour each.

Two 8,770 lb. per hour conical ball mills per boiler are each direct connected to a burner. Sensitive and prompt response to feed adjustment is provided by two fans, each with a branched outlet, one leading to the burner pipe, the other to the mill return air. One fan handles only incoming air, and the other only coal-laden air. Splitters operating in opposite sense are applied in each fan branch casting and connected to the coal feeder screw. For example, at 30 per cent maximum load, the splitter on the coal fan is set so that 30 per cent of its coal-laden air goes to the burner and 70 per cent to the mill. On the air fan 70 per cent goes to the burner, and 30 per cent to the mill. The primary air volume supplied to the burners is thus almost constant for all loads.

Both primary and secondary air are preheated, but to guard against blow-back at light loads or when starting up there is an adjustable spring damper opening into the mill fan inlet duct to maintain a predetermined suction at the fan. Adjustment of the spring loading gives opportunity to temper the air to the mill if the preheat is too high.

The three forced-draft fans, each having an air-moving capacity of 200,000 lb. per hour against a head of 12½ in. of water pressure, are of the conoidal, turbovane design. One fan is used per boiler, without interconnection. Air is forced through a plate type air preheater, then through parallel ducts on both sides of the boiler.

Forced-draft dampers are automatically operated by the Smoot system to maintain constant furnace pressure. All forced-draft fans are driven by motors having double windings for operation at two speeds, namely, 1,750 r.p.m. at maximum pressure and air delivery, and 875 r.p.m. at lower ratings.

Each air preheater has a heating surface of 11,550 sq.ft. and is capable of raising fresh air from 90 deg. to 450 deg. at maximum boiler rating. Three such preheaters and three induced-draft fans are used, one set per boiler. The induced-draft fans are driven by two-speed motors at 1,150 r.p.m. at higher ratings and at 575 at lower steam output. They are connected to a common flue, which, in turn, discharges to a stack 8 ft. 6 in. in internal diameter by 225 ft. high. A cyclone cinder catcher is directly connected with each induced-draft fan.

With experience in other high pressure plants as a guide, it was decided to use welded piping for the high-pressure steam and water systems. As few flanged joints as possible were used, these being of the Van Stone type with copper-coated steel gaskets. Line welds of the sleeve

Principal New Power Plant Equipment Installed

Turbine generators, two, 3,750 kva.....Allis-Chalmers Mfg. Co.
Boilers, three, single, cross-drum, 3-pass inclined water-tube, 10,760 sq.ft. each .....Springfield Boiler Co.
Water walls, three sets, 2,050 sq.ft. each....Springfield Boiler Co.
Superheaters, 140 deg. F. at 350 per cent rating, 2,220 sq.ft. each .....Superheater Co.
Coal-weighing scales, six, 200 lb. capacity per discharge, Richardson Scale Co.
Pulverized-coal burners, six, 2 per boiler, 8,770 lb. coal per hr. for each burner .....Peabody Eng. Corp.
Pulverizing mills, six, mill fans and coal feeders, 2 per boiler, 8,770 lb. coal per hr. each..(Hardinge)—Foster-Wheeler Corp.
Coal conveyors, two, Peck carrier and scraper.....Link Belt Co.
Forced-draft fans, three, turbovane, 200,000 lb. per hr. at 90 deg. F. .....B. F. Sturtevant Co.
Boiler-feed pumps, three, 5 stages, 575 lb. pressures, 400 gal. per min. steam turbine driven.....Dean Hill Pump Co.
Boiler feed pump governors.....Fisher Governor Co.
Air preheaters, three, Thermix, 11,550 sq.ft. heating surface, each .....Prat-Daniel Corp.
Induced-draft fans, three, 220,000 lb. gas per hr. at 500 deg. F., Prat-Daniel Corp.
Cyclone cinder catchers, three, 5 ft. dia. x 10 ft. high, Prat-Daniel Corp.
Soot blowers, 14 elements per boiler, Diamond Power Specialty Corp.
Feed-water system, 28,000 gal. per hr. filters, deaërators, and hot process softener .....Cochrane Corp.
High-pressure heaters, two, 625 sq.ft. each, 218 deg. to 350 deg., Croll Reynolds Engineering Co.
Ash hoppers and sluicing system.....Allen-Sherman-Hoff Co.
Ash-sluicing pumps, 100 gal. per min., 110 lb. press., motor driven.....Allis-Chalmers Mfg. Co.
Ash-sluicing pumps, two, 1,000 gal. per min. 110 lb. press., motor driven .....Allis-Chalmers Mfg. Co.
Deconcentrator .....Henzey Deconcentrator Co.
Combustion control .....Smoot Engr. Corp.
Instruments:
Pressure gages: .....Crosby Steam Gage & Valve Co.
Pressure recorders .....C. J. Tagliabue Mfg. Co.
Thermometers .....C. J. Tagliabue Mfg. Co.
Draft gages .....Bailey Meter Co.
Flow meter .....Bailey Meter Co.
Temperature recorders.....Bailey Meter Co., and Tagliabue
Water meters, Venturi.....Builders Iron Foundry
Feed-water regulators, 4 in., type E.....Stets Co.
Vertical ash dredge pumps, two, 1,000 gal. per min., Morris Machine Works
Piping.....Midwest Piping & Supply Co.
Valves .....Crane Co.
Blow-off valves .....Yarnall-Waring Co.
Flues, dampers, and air ducts.....Connery & Co.
Desuperheater .....Smoot Engineering Corp.
Chimney alterations .....Weiderholdt Const. Co.
Third-pass soot removal systems.....Girtanner Eng. Corp.
Cyclone and preheater ash sluicing systems, three sets, cyclone, Girtanner Eng. Corp.
Stop and check valves, non-return, 8 in., 600 lb., Schutte & Koerting Co.

type are used everywhere except at valves and equipment or where the necessities of construction demanded a break.

The heat balance is such that, for the present, a considerable amount of 450-lb. steam will pass the reducing valves at nearly all loads, as the turbines do not require the full amount of steam to generate the necessary electric output. But the electric load should increase faster than steam process load, since a steam-driven ice machine and steam auxiliaries will probably be electrified in the future. Then the turbines will take nearly all of the steam.

Since the accumulator will handle most of the short-time load swings, the boilers will operate the same as in the past, largely at slowly varying loads. It was therefore unnecessary to provide full automatic combustion control. Regulation is of the oil-powered mechanical type. Primary control is from fuel feed on the mills, the system adjusting uptake damper and induced-draft fan speed. For constant air-fuel ratio, the forced-draft damper and fan speed are controlled from furnace draft. Automatic CO_2 correction is applied as a refined adjustment.

The draft system as a whole is designed for 15 per cent CO_2 at 155,000 lb. steam per hour per boiler, but by the use of two small bypass ducts at the preheater, one for air and one for gas, it is possible to operate down to $12\frac{1}{2}$ per cent CO_2 at maximum load, if particularly bad coal should require it.

The reducing valves are followed by a desuperheater of the "carbureting" type, which keeps the high temperature out of the 140-lb. lines. This desuperheater consists of a Venturi "chute" into which a nozzle projects. The nozzle is supplied with condensate through a float-controlled regulator. The water spray is drawn into the high velocity steam in the chute in proportion to flow. Operation is entirely automatic, and the amount of desuperheat can be adjusted for any temperature down to saturation.

Turbines are designed to bleed a maximum of 155,000 lb. per hour at 140 lb. gage, and exhaust at 5 lb. gage back pressure. Each machine will carry 3,125 kw. at no bleed, but could carry up to 4,600 kw. with full bleed and exhaust if the generator could take this load. Regulation is so adjusted that the 140 lb. bleed will supply steam as required up to a predetermined maximum capacity, after which the reducing valves start to open.

Recording instruments are provided for every pressure, temperature, and flow of water or steam needed to make a complete heat distribution in the plant. Indicating instruments are used for all other items. All indicating and recording instruments needed for the operation of each boiler are mounted on individual boiler panels set near the coal feed controls. The operator can also see his gage board from all hand control positions on fans and dampers.

All general indications and records, such as steam manifold pressure load, boiler-feed header pressure, and bleeder mains, are collected on two main panels, one in the turbine room and one in the boiler room.

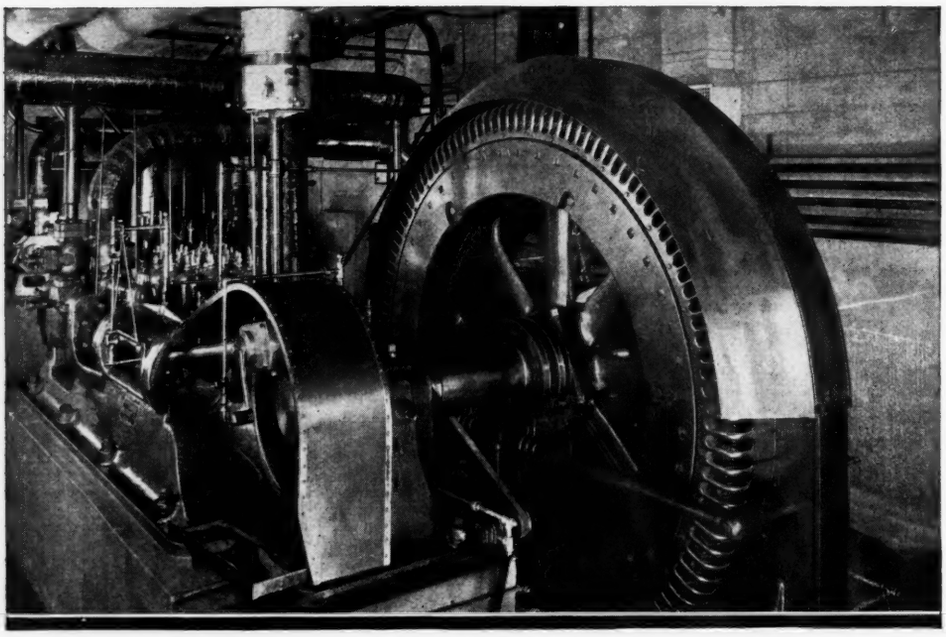
In addition to the spare capacity, a connection to the lines of the Union Electric Light Company, sufficient to operate the auxiliaries for one boiler at half load, is retained for emergency use.

An elaborate system of interlocks is provided to prevent the wrong sequence in starting and stopping firing equipment and fans.

Since the first week in January of this year either one of the two first boiler units has been in operation, developing from 35,000 lb. to somewhat over 140,000 lb. of steam per hour. In addition, the completed boiler feed-water treating system has been functioning. It is worthy of note that when operating at a variable load with from 14 to 16 per cent of CO_2 no slagging of the ash has resulted, and that the absorption of heat by radiation and some convection of the water walls exceeds calculations by approximately 25 per cent, resulting in lower steam superheat, lower air preheat, and lower stack temperatures than anticipated. This is shown by the following comparison of calculated and actual results:

Steam Produced, Lb. per Hr.	Description of Item	Calculated	Actual
125,000	Over-all boiler eff. (including air heater)	81.2	83.8
	Flue gases leaving boiler, deg. F.	684.0	610.0
	Superheat, deg. F.	137.0	120.0
105,000	Over-all boiler eff.	81.9	84.5
	Flue gases leaving boiler, deg. F.	648.0	578.0
	Superheat, deg. F.	127.0	109.0

The plant log for a period of twenty days with a daily steam load ranging from a minimum of 66,000 lb. of steam per hour to a maximum of 125,000 lb. gave an average over-all boiler plant efficiency of 80 per cent on hand regulation of the induced-draft damper, according to the air-flow steam-flow pens of a boiler meter.



A 400-hp. synchronous motor connected to a CO_2 compressor in a theatre

A. C. Motors for Pumps and Compressors

By H. L. SMITH
Industrial Engineering Dept.
General Electric Company

Pumps and compressors represent a large part of the power load in many buildings. The use of alternating current has created new problems in applying motors. This article tells how they have been solved

ALTHOUGH not frequently called upon to operate, the fire pump is one of the most important units in a building. Fire pumps are likely to stand idle for long periods, though they should be started periodically to be sure that everything is functioning properly. When these pumps are required they must surely operate. For this reason the motors, pumps, and control should be as simple and be made as reliable as it is possible to build such units. Either manual control or combined manual and automatic control may be used, as is decided by the owner's preference, underwriters' rules, and city ordinances. If manual control and constant-speed operation are required, induction motors of either squirrel-cage or wound-rotor types may be used. A squirrel-cage motor and control have the lowest first cost. Whether a squirrel-cage motor can be used will depend upon the power supply. If the generator, transformer, and line capacities are ample to start the motor under the worst condition a squirrel-cage motor is acceptable. It is advisable to consult the underwriters' representative.

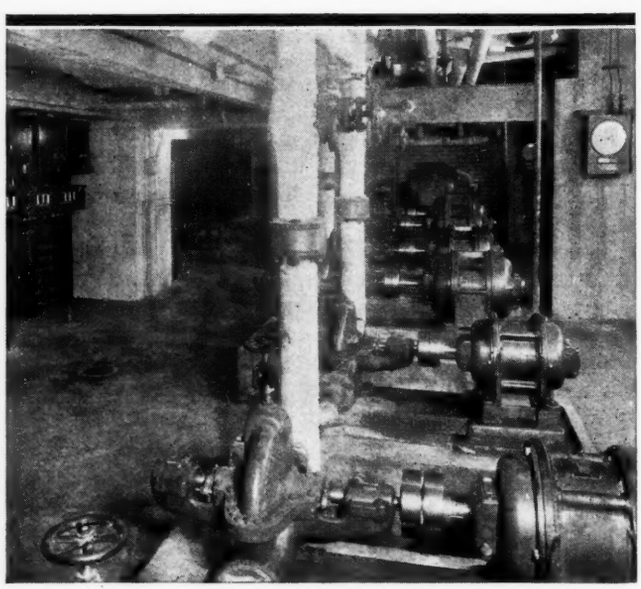


Fig. 1—Seven squirrel-cage induction motors driving house pumps in a bank building

If the power supply is not adequate to start a squirrel-cage motor, if there are limitations on the permissable starting current, or if adjustable speed is required, it is necessary to use a wound-rotor induction motor. Even where wound-rotor motors are used, it is usual to run them at constant speed. However, adjustable-speed, wound-rotor motors are sometimes found in the taller buildings where it is desirable to have different speeds, depending upon the floor to which the water must be pumped.

Combined manual and automatic control is always used where the pump feeds a sprinkler system. Normal operation is automatic, with manual operation provided to permit of starting the motor if anything should make the automatic features inoperative at a time when it is needed.

A large number of buildings requiring fire protection are not so constructed as to be able to support a tank of sufficient capacity for the sprinkler supply. Here, the underwriters permit what is sometimes called a booster pump. These pumps are generally driven by 20 to 50-hp. motors, though occasionally they may require as high as 75 hp. The motors are of a special squirrel-cage design started on full voltage if power supply permits, and are equipped with supervisory control.

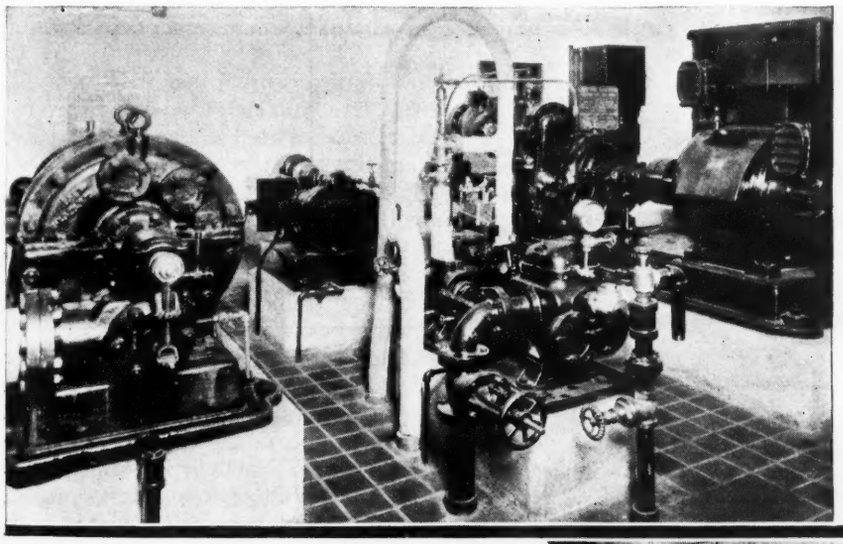


Fig. 2—A 150-hp. self-ventilated induction (on the right) drives a fire pump in a department store

Two forms of mechanical construction are allowed. The motors may be of the open type designed for a 40 deg. F. temperature rise, or they may be inclosed, self-ventilated 40-deg. motors. The latter are constructed so that there are no holes below the center line of the motor. The leads are brought out at the top of the frame, and mesh screens are placed over the inlet- and outlet-air openings. In both cases the motors must be substantially constructed with special insulation to meet the moisture conditions in this service. Sleeve-bearing motors must have split-end shields and split bearings on the coupling end to permit of quick replacement of bearings and dismantling of the motor in case of a failure.

The open-type motor is generally used, as it is considerably cheaper than one of inclosed, ventilated construction. However, the pump builder must provide a metal plate between the pump and motor to prevent water being sprayed into the motor. A fire pump driven by a totally inclosed self-ventilated motor is shown at the right in Fig. 2, and an open-type motor with a protective plate between the motor and pump is shown in Fig. 3.

Manual controllers may be inclosed in a splash-proof ventilated inclosing case or, if so located as to be protected against water, they may be open. Combined manual and automatic controllers must always be inclosed.

Sump pumps are required to discharge into the sewer any water that collects in the basement, and, in some cases, low-level sewage is also pumped into the sewers. These are practically always vertical units, as in Fig. 6, and the sizes permit of the use of squirrel-cage induction motors started directly on full voltage, although it is sometimes necessary to include reduced-voltage starting equipment. These units perform an important function. As a shutdown may involve flooding of a basement, they are generally installed in pairs and have a high- and a low-water alarm panel.

Various combinations of control have been worked out for use with these units, but there are four common controls for squirrel-cage induction motors in this service. One is a duplex controller for use with a single motor. Fig. 5 shows such a controller for one squirrel-cage motor started on full voltage. It consists of a fused line switch; two line contactors; a temperature relay; a four-pole, double-throw switch for transferring the motor to either line contactor; and a two-pole, double-throw

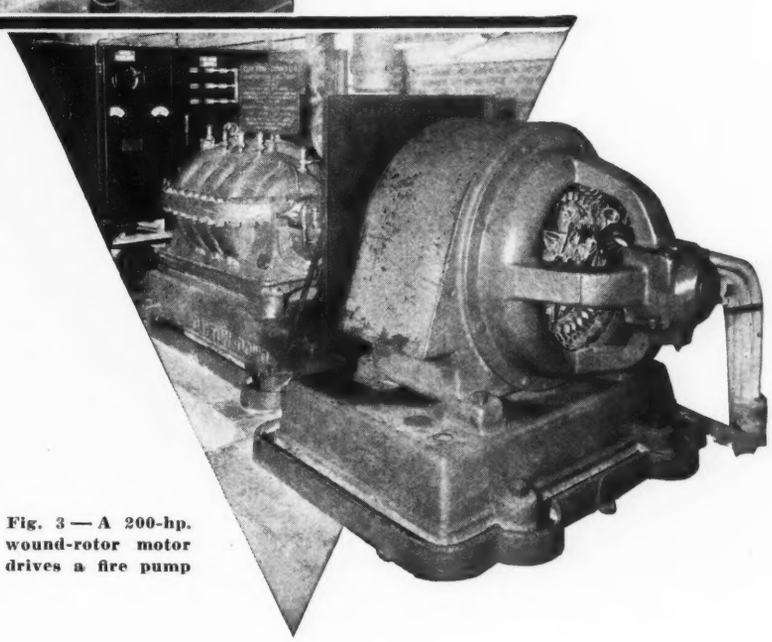


Fig. 3 — A 200-hp. wound-rotor motor drives a fire pump

control switch, one side to connect the controller to a float or pressure switch, the other to permit of starting or stopping the equipment independently of the float or pressure switch. Another form of this equipment is similar to that just described, but the motor is started through a primary resistance instead of on full voltage.

A duplex controller for two motors is another form of starting equipment for sump pump motors. Fig. 4 shows this type of unit for two squirrel-cage induction motors started on full voltage. The control consists of two fused line switches; two magnetic line contactors with temperature overload relays; a six-pole, double-throw switch to transfer either motor to either starter; and a four-pole, double-throw switch to transfer the control circuit. Each equipment has a single-pole, double-throw switch to permit of operation from the float switch, or pressure switch or independent control. With this arrangement both motors may be operated at the same time from float switch or pressure switch, or they may be operated independently of the float switch or pressure switch. This control is also available in a form similar to Fig. 4, except the motors are started through primary resistance instead of on full voltage.

The high- and the low-water alarm panel consists, essentially, of a disconnecting switch, an alarm bell with a switch and a red and a white indicating light. This equipment gives an audible and visible warning when the water reaches a dangerous level, either too high or too low. When the water is too high, the alarm is sounded and the red lamp lights. A switch is provided for the operator to silence this alarm, but as soon as normal conditions are reached an undervoltage coil de-energizes and the switch goes back to the normal position, reconnecting the alarm back into circuit to sound again if a dangerous condition exists. The lights are so connected that even with the alarm silent, the red light will continue to glow until a normal condition prevails. Extremely low levels are similarly indicated by the white light. The float switches used to operate this panel are separate from that used to start and stop the pump, with separate switches for the high- and the low-levels.

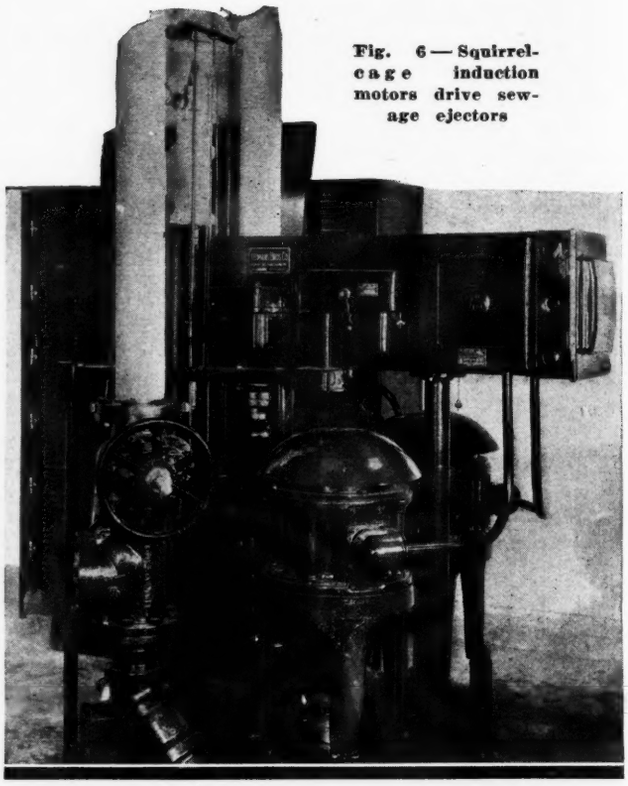


Fig. 6 — Squirrel-cage induction motors drive sewage ejectors

In many buildings the city pressure is not sufficient to supply water to all floors, and house tanks are installed on the roof and at other levels, water flowing from them by gravity to the floors below. These tanks are supplied with water from service or house pumps operated at constant speed, the pumps being started by a float switch in the tank, or by pressure-control switch. Squirrel-cage induction motors are generally used, the tendency being toward full-voltage starting, though certain cases require reduced voltage. These motors should be of the open 40-deg. type.

House-tank pumps are as important as sump pumps, and are frequently installed in pairs, with duplex control as previously described for the sump pumps and shown in Figs. 4 and 5.

In buildings with hydraulic elevators it is general practice to use pressure-controlled pumps, which, during rush periods, require frequent starting of the motors. Starts during the rush period are made as frequently as 45 times an hour. A normal-torque, high-reactance, squirrel-cage motor started on full voltage through a magnetic switch will generally be the simplest, but it is necessary to check the motor for heating

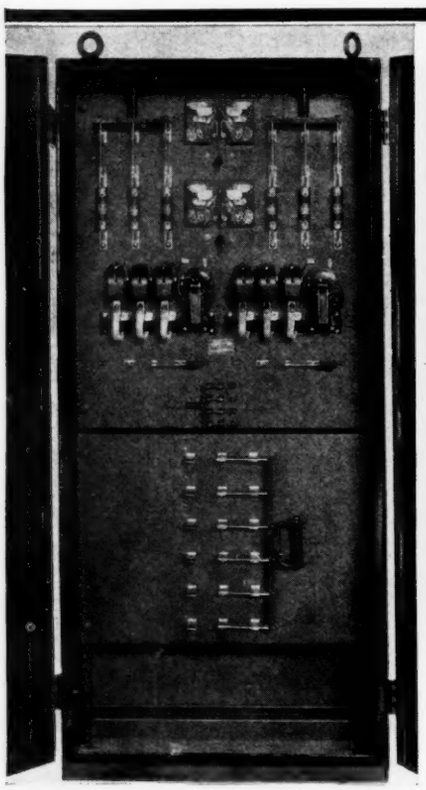


Fig. 4—Duplex controller for two sump pump motors

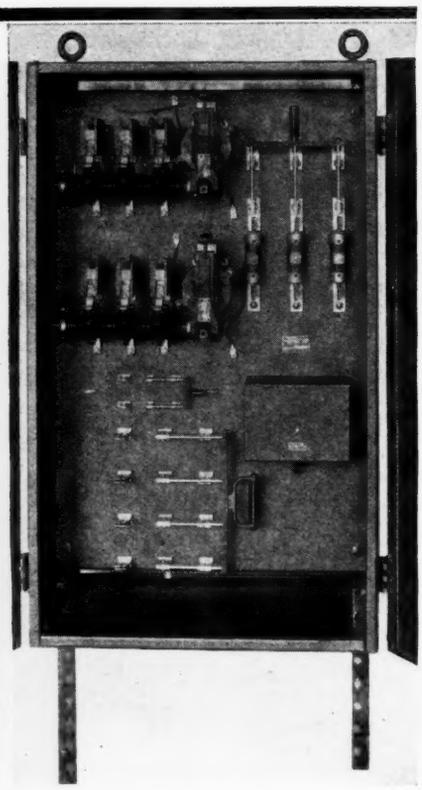


Fig. 5—Duplex controller for one sump pump motor

on the maximum number of starts per hour in the duty cycle.

Occasionally, motors and control are required for boiler-feed, condenser-circulating, circulating-water pumps and ice-water-circulating pumps. These are generally small units using constant-speed, squirrel-cage induction motors.

A greater number of compressors, both reciprocating and centrifugal, are being used in buildings than ever before. These range in size from small units requiring less than 5 hp. to supply small amounts of compressed air, up to units requiring from 400 to 500 hp. in refrigeration and air-conditioning work.

Centrifugal compressors used for this service are frequently driven by wound-rotor induction motors, as a certain amount of speed regulation is necessary. Control consists of a primary switch, which may be an oil circuit breaker or contactor, and a drum controller with resistor for starting and speed control.

It is the accepted practice on reciprocating compressors to use direct-connected synchronous motors except on the very small sizes, where squirrel-cage motors give the most economical combination.

Reciprocating compressors have a definite, recurring pulsating torque, which tends, through the synchronous motor, to set up pulsation in the electrical system. It is necessary, therefore, on any of these drives to have a synchronous motor designed with the proper electrical characteristics and fly-wheel effect, in conjunction with the compressors, so as to keep the pulsation within set limits.

Calculating Heating Value From Chemical Composition

By H. L. Kauffman

THE growing use of coal and related fossil fuels as a source of power has created interest in means for calculating the heating value of such fuels from their chemical composition, that is, from the ultimate analysis of the fuel. The advantage of ascertaining heating value from a chemical analysis lies in the fact that it gives a check of calorimetric determination; and makes it possible to find the heating value of a fossil fuel when a calorimeter is not available.

Until a few years ago Dulong's formula was the one most widely used for making such calculations. Concerning this formula and its use Marks, in his "Mechanical Engineer's Handbook," page 633, has the following to say:

"The calorific value of a fuel may be approximated by computing the various calorific values of its constituents as shown by the ultimate analysis. Dulong's formula, which follows, gives results within 1½ per cent of the actual for most coals not high in moisture:

$$\text{B.t.u. per pound} = \frac{1}{100}\,[14{,}544\ C + 62{,}028\ (H - \tfrac{1}{8}\ O) + 4{,}050\ S]$$

where C = per cent of carbon,
H = per cent of hydrogen,
O = per cent of oxygen,
S = per cent of sulphur.

"This formula assumes that all the oxygen in the coal is combined with part of the hydrogen to form water, the remaining hydrogen being available for combustion, together with carbon and sulphur."

In Dulong's formula the term $H - \frac{1}{8}\ O$ is called the "available" or "disposable" hydrogen.

Dulong's formula has, in general been found to give, for the majority of the common varieties of coals, results that are accurate within the limits of error of chemical analyses and calorimetric determinations. However, for lignites and cannel coals the error has been excessive when calculating calorific value by this (Dulong's) method.

W. Steur *(Brennstoff-Chemie 7,344-7, 1926)* proposes another formula, that he says gives accurate results for the lower grade coals, stating: "Results for a number of coals of all ranks, from peat to anthracite, show a maximum variation between the calculated (using the formula developed by Steur and shown below) and determined heating value of 40 calories, and usually the calculated result is within 25 calories of the determined result."

Steur's formula is as follows:

$$H_o = 81\ (C - \tfrac{3}{8}\ O) + 57 \times \tfrac{3}{8}\ O + 345\ (H - \tfrac{1}{16}\ O) + 25\ S_b$$

C = per cent of carbon,
O = per cent of oxygen,
H = per cent of hydrogen,
S_N = per cent of combustible sulphur from the elementary analysis.

To get B.t.u. per pound, the result obtained from the use of Steur's formula must be multiplied by 1.8.

The formula developed by Steur is based on the assumption that half of the oxygen content of the coal is combined with carbon and the other half with hydrogen. The oxygen is assumed to be combined with the carbon as carbonyl, which has a heating value of 5,700 calories per gram of carbon.

Despite the evidence given by Steur as to the accuracy of the results obtained by the use of his formula, at least one investigator has taken exception, namely, R. Vondracek, who says *(Brennstoff-Chemie 8, 22-3, 1927)* that "the formula proposed by Steur for the calculation of heating value from the elementary analysis does not give good results." Vondracek proposes, instead, the formula:

$$\text{Calorific value} = (78.6 + 2.8\sqrt{100 - C^1})\ C + 270\ (H - 0.1\ O) + 25\ S$$

In this formula C^1 indicates the carbon content of pure coal in per cent, and C, H, O and S, indicate the per cent of carbon, hydrogen, oxygen and sulphur in the coal, the heating value of which is being calculated. *To get B.t.u. per pound, multiply the results obtained from the use of Vondracek's formula by 1.8.*

Vondracek found that within the limits 90 to 95 per cent, C is nearly linear with the quantity in the brackets, so that for this range the equation may be written:

$$\text{Calorific value} = (89.1 - 0.062\ C^1)\ C + 270\ (H - 0.1\ O) + 25\ S$$

In the article in which Vondracek announced his formula, he states that Steur tested his formula upon six fuels investigated by Langbein and six by himself, but that neither Steur's nor his formula gives satisfactory agreement with Langbein's determined results. Vondracek explains the failure of his formula to apply to Langbein's coals as due to the difficulty in getting correct analytical figures for the pure carbon and in arriving at the actual oxygen content.

SPHERICAL THRUST BEARINGS

Take Vertical and Horizontal Loads

FOR MANY YEARS the flat-type Kingsbury thrust bearing has been employed extensively where thrust loads have to be carried. Such bearings are built for loads up to 1,500,000 lb. on large watewheel generators. This type of bearing has a disk thrust plate keyed to the shaft, that is supported on a number of shoes. The shoes are segments of a flat ring and are pivoted on their under side. When the shaft revolves the shoes tip sufficiently to allow a wedge of lubricant to form between the revolving plate and the shoes. This wedging action establishes an oil film between the revolving and stationary parts that prevents metal-to-metal contact in the bearing. Bearings of this kind have been operated for years without the tool marks being worn from the wearing surfaces.

With the flat-type bearing, steady bearings are required on the shaft. For the satisfactory operation of these bearings they require considerable clearance, very careful alignment, and the shaft is not held as rigidly as might be desired under certain conditions. To overcome this difficulty a spherical thrust bearing has been developed by Albert Kingsbury, president Kingsbury Machine Works, Philadelphia, Pa. One of these bearings partly assembled is shown in Fig. 1, and a cross-section in Fig. 2. At the top of Fig. 2 is the circular key that transmits the load from the shaft to the bearing. This key is made in two halves and is bolted to the thrust block (also made in two halves and keyed to the shaft). The thrust block is bolted and doweled to the bearing runner, the under surface of which is spherical. Thrust shoes with concave surfaces support the bearing runner. In so far as the operation of the bearing is concerned, it is practically the same as the standard flat type. With the latter, however, direction of thrust is parallel with the shaft's axis and does not add any steadying force to hold the shaft in a central position. In the spherical type the shoes are so placed that their reactions are along the surface of a cone, which makes an angle of 30 deg. with the shaft, as indicated in the figure. The apex of this cone is in the axis of the shaft, hence the shoes hold the shaft in a central position.

One of the important advantages of the spherical bearing is the rigidity with which it holds the axis of the shaft in one position. Ordinary steady bearings have considerable running clearance, and when the shaft is subjected to a side load it can shift an appreciable amount

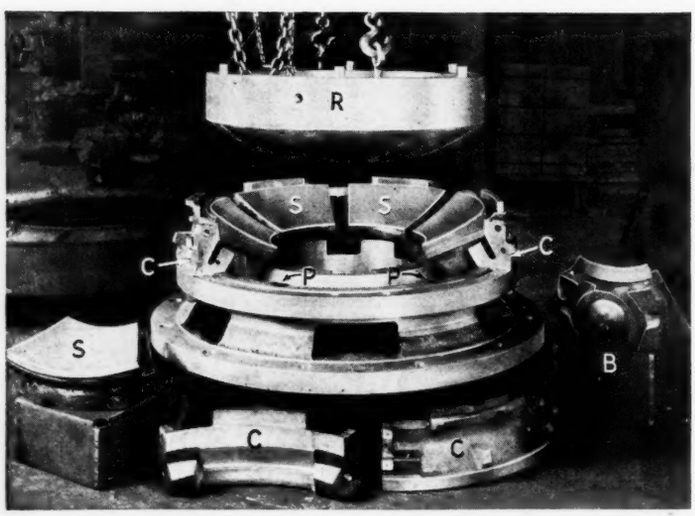
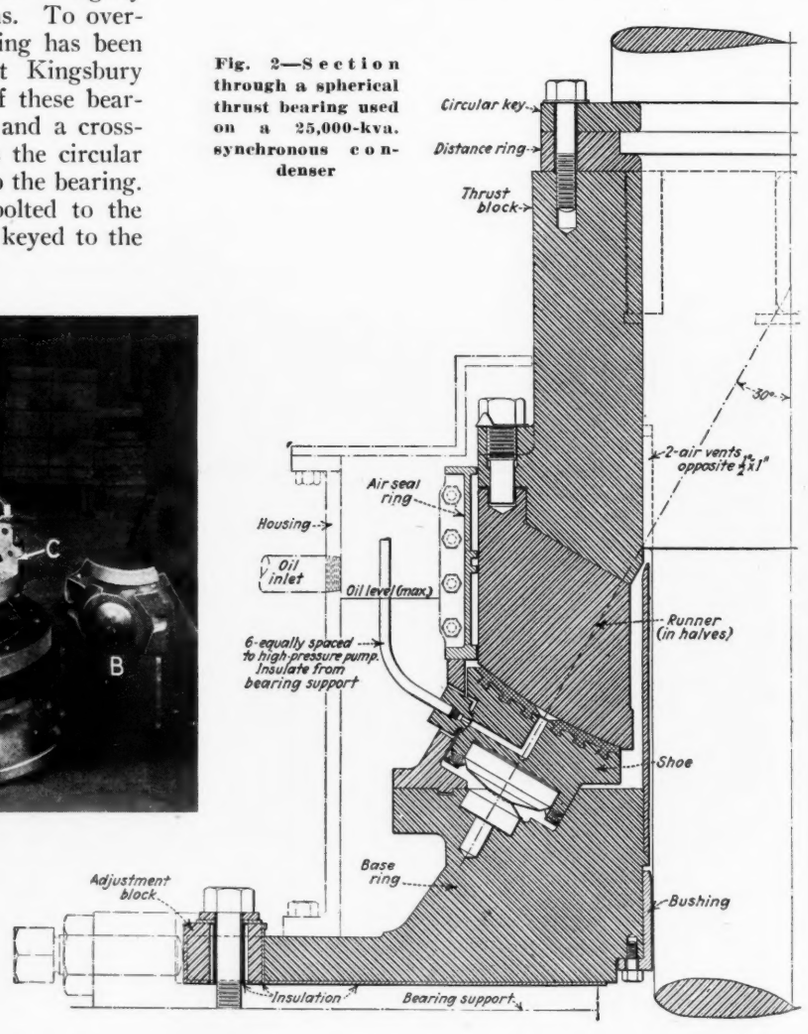


Fig. 1—Parts of a hydro-electric, unit spherical bearing partly assembled

Fig. 2—Section through a spherical thrust bearing used on a 25,000-kva. synchronous condenser



in any direction. Freedom to shift within the bearing is not present in the spherical bearing, and a very much closer running position of the shaft is obtainable. This makes possible the use of smaller clearances in the seals of the hydraulic turbine, and is also important when the air gap of the generator is small. The bearing can be made of the concave runner type for use just above a waterwheel, or of the convex runner type for use below the rotor of a generator.

The running-position stability obtained with the spherical bearing will be evident from the following: Oil-film thickness in a Kingsbury bearing varies somewhat with the speed, load, and viscosity. In an average large bearing it can be assumed that the mean film thickness is about 0.002 in. A side load of 6 per cent of the vertical load would shift the shaft in a 30 deg. spherical bearing less than 0.0005 in., a 13 per cent load not more than 0.001 in., and a 20 per cent side load not more than 0.0015 in. This shifting is that caused by changed oil-film thickness as a result of side load, and has nothing to do with the elasticity of the bearing mounting. To obtain the foregoing results, the mounting is made relatively rigid against side movement at the sphere's center.

Fig. 1 shows the parts of a spherical thrust bearing partly assembled. The runner *R* is suspended above the partly assembled shoes *S*. One of the shoes, at *B*, clearly shows the support. When the shoes are in position they are carried on the base ring plugs *P*. The retaining ring *C* is made in as many sections as there are shoes. This arrangement allows of removing any of the shoes without disturbing the others.

The spherical bearing takes the place of two bearings, and should therefore be less expensive when builders are accustomed to it and take full advantage of its possibilities. Its use eliminates one steady bearing and the difficulties of aligning these bearings.

Automatically Lubricated

As well as performing the function of two bearings, the spherical bearing is automatically lubricated. It is difficult to adequately lubricate automatically a cylindrical steady bearing, whether placed above or below the thrust. It involves the use of a pump and other equipment, whereas the spherical type adds no complications to the simplicity of oil circulation within a Kingsbury bearing.

In Fig. 2 a pressure oil pipe is shown going to the center of the shoe. This bearing is used on a 25,000-kva. vertical synchronous condenser. To keep the break-away torque as low as possible at starting, pressure oil is applied to the shoes beforehand. After the machine has been started the pressure oil is shut off and the bearing is lubricated in the usual way.

Water cooling can be applied to the spherical bearing as readily as to the flat type. Its runner can be made in halves for ready replacement, and can be insulated. Air-seal rings may be employed, and any speed is possible. Adjustment of the spherical bearing must, however, be accomplished in a different manner. The convex-runner type can be used with a split thrust block, above which a distance ring is mounted just below the ring key. This distance ring is made in halves and can be machined to obtain the proper adjustment in the bearing. Adjustment can also be accomplished by raising or lowering the base ring.

The spherical bearing can readily be made so as to be adjustable sidewise for bringing the shaft into the desired running position with respect to the generator or turbine. This side adjustment is made and the bearing insulated, when necessary, as in Fig. 2. Double wedge blocks are fitted to the four corners of the extended base-ring flange and back up against lugs on the bearing support.

These bearings are built for a wide range of applications. One is for 15-hp. vertical motors operating at 1,800 r.p.m. driving deep-well pumps with a vertical thrust load of 2,500 lb. Another application is on a 25,000-kva. vertical synchronous condenser operating at 500 r.p.m. A third application, on a waterwheel, comprises a 45-in. bearing carrying a thrust load of 324,000 lb. and operating at 128.6 r.p.m. This bearing is designed to stand the runaway speed of the unit, 250 r.p.m. A 17-in. bearing is being built for a load of 1,000 lb. per square inch at 50 r.p.m. The loading on this bearing is about three times that allowed in the usual design.

Poland's Power Possibilities

AN IMPORTANT problem with which Poland is now confronted is that of national electrification and the rational employment of the country's resources of power to this end. The following figures indicate the progress of Poland since the formation of the Republic:

	1914	1928
Number of power stations	113	369
Rating in kw	172,600	341,761
Wattage per capita	6.35	12.57

Although the generation of current has shown a corresponding growth, it is still far below the country's actual needs. The last production figures available, those for 1927, show that 2,302,000,000 kw.-hr. was generated in that year, or 84 kw.-hr. per capita. Production by public utility undertakings was 876,000,000 kw.-hr., or 32 kw.-hr. per capita. The present estimated annual requirements of electric energy, on the basis of existing industrial plants, amounts to 5,200,000,000 kw.-hr., or more than double the current output.

The fuel reserves for future extensions are both varied and plentiful. Existing coal fields are estimated to contain over 60,000,000,000 tons, while undeveloped water power in the Carpathian Mountains and in the former German provinces is stated to be as high as 1,000,000 kilowatts.

Poland's three largest power stations are at Chorzow, Lodz, and Grodek. The first of these, in Upper Silesia, is the largest in Poland. Its generating capacity in 1923 was 60,000 kw., but has since been increased to over 80,000 kw., while the output has risen from 195,000,000 kw.-hr. in 1923 to 442,000,000 kw.-hr. in 1928. This station supplies current to a large proportion of the highly industrialized Upper Silesian coal field, and it is anticipated that further extensions will be effected in the near future.

Poland's second biggest station is at Lodz, the textile center. The progress shown by this plant during recent years is remarkable. Its capacity in 1923 was 28,900 kw., but by 1928 this had been increased to 45,850, while output had grown in the same period from 55,000,000 to 98,000,000 kw.-hr. and the number of consumers had been increased nearly three and one-half times. A 22,000-kw.-hr. turbine set is to be installed this year to meet the continued growth in demand.

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By R. M. ROTHGEB
Chief Engineer
N. C. State Hospital

North Carolina State Hospital decreases power plant cost by purchasing coal that gives cheapest steam and by reducing engine exhaust pressure

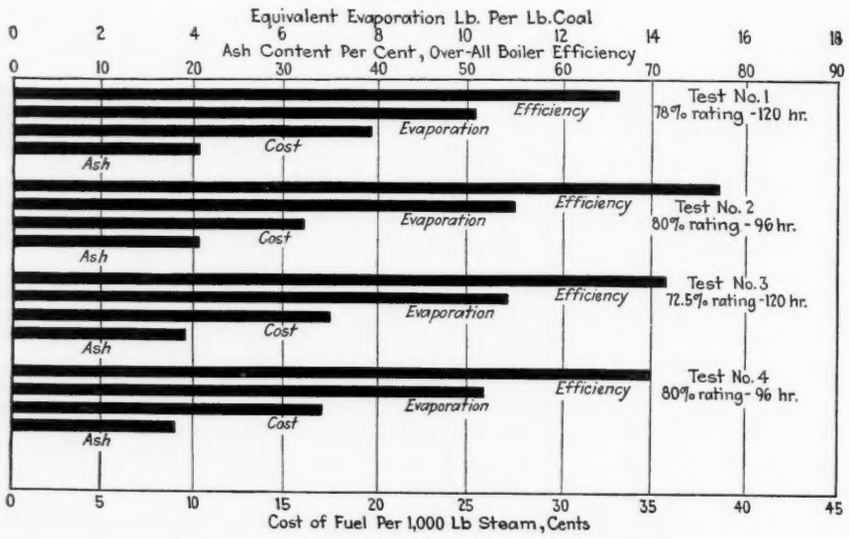

Equivalent Evaporation Lb. Per Lb. Coal
0 2 4 6 8 10 12 14 16 18
Ash Content Per Cent, Over-All Boiler Efficiency
0 10 20 30 40 50 60 70 80 90
Test No. 1
78% rating - 120 hr.
Efficiency
Evaporation
Cost
Ash
Test No. 2
80% rating - 96 hr.
Test No. 3
72.5% rating - 120 hr.
Test No. 4
80% rating - 96 hr.
0 5 10 15 20 25 30 35 40 45
Cost of Fuel Per 1,000 Lb Steam, Cents

Fig. 1—Comparison of fuel costs for different kinds of coal

ECONOMY of operation seems to be the outstanding need in a great number of smaller industrial power plants and in the power and heating plants serving institutions. The larger state-owned plants, as a rule, have competent operating engineers, but often they are handicapped by responsibilities outside of plant maintenance and operation, so that they cannot give to the power plant the time and thought necessary for economical operation.

Fortunately for industrial plants, the manager is usually a keen economist looking for improvements to reduce manufacturing costs, but with state institutions the man suited to direct its educational or medical functions is often not well versed in the technique of economical power plant operation or economic utilization of services rendered by such plants. The operating engineer, therefore, lives in a world to himself, because of this lack of sympathy and understanding.

First and most important of all in economical plant operation is the selection of coal that will produce the cheapest steam. There are, of course, some factors that must be considered together with steam costs, such as the boiler ratings that can be obtained with different grades of coal, difficulty experienced in burning the various grades, methods of handling ash and its disposal and maintenance of furnace and grates.

Fig. 1 gives data on actual boiler tests for four different grades of coal. These tests were made during August, 1928, in the power plant of the State Hospital at Raleigh, N. C., and the conditions under which each test was run were made as nearly alike as possible. In test No. 2 steam was produced at a fuel cost of 16c. per 1,000 lb., while in test No. 1 the fuel cost was 19.6c. per 1,000 lb. This represents a difference of 18 per cent in fuel costs, and if the tests are typical of results obtained in everyday practice, as we endeavored to make them, then this percentage applied to a fuel bill of $31,300 (which was the amount expended during the fiscal year 1927-28 for this plant) would make a reduction of $5,640 in the fuel bill.)

The coal used in test No. 1 had been burned in this plant for several years, but as a result of the tests we purchased, for the following year, the coal used in No. 2 test, and our resulting fuel costs ranged between 16 and 17c. per 1,000 lb. of steam, proving that our tests were nearly typical of everyday results. No. 2 was a low-grade high-ash coal, but could be purchased at a low price, and the high ash content was not particularly objectionable for our conditions. The high ash shown in chart No. 1 on all four grades of coal is by weight and is caused by saturating the refuse with water before removing it from the ashpit. Tests on this ash showed water 40 per cent, carbon content 20 per cent and dry ash 40 per cent.

The coal used before the tests was bought by the purchasing department of the institution on a cost-per-ton basis without any regard for the results obtained in the boiler room. It had a high volatile content, carrying a higher freight rate than low-volatile coal. As the high volatile content was a most undesirable characteristic for this plant, because the boilers were set unusually low, making complete combustion almost impossible, the fallacy of such purchasing is quite evident.

The cost of fuel per 1,000 lb. of steam shown in Test No. 1 is:

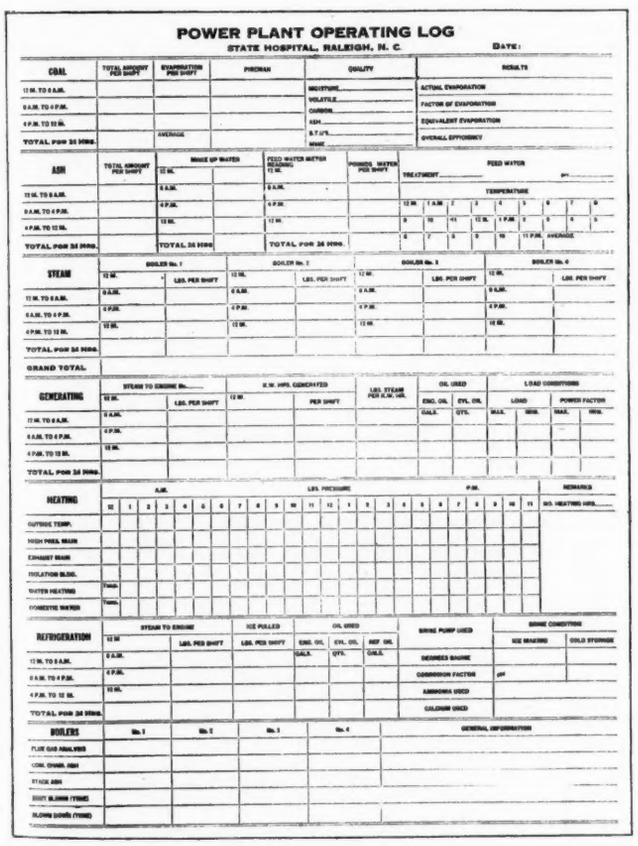
$$\frac{1{,}000 \times (\textit{cost per ton coal delivered})}{(\textit{Equiv. evap. per lb. of coal}) \times 2{,}000}$$

applying this equation to No. 2 coal, which cost $3.50 delivered, the fuel cost of the steam is:

$$\frac{1{,}000 \times 3.50}{11 \times 2{,}000} = 16\text{c., nearly}$$

Using this formula one can readily obtain the price that can be paid for one coal to meet the competition of another, provided, of course, enough of the coal has already been burned under test to know approximately the evaporation that can be obtained from it. Coal No. 1 gave an evaporation of 10.1. To find the price that can be paid for this coal to meet steam costs produced from No. 2 coal we have:

$$\textit{Cost per ton} = \frac{0.16 \times 10.1 \times 2{,}000}{1{,}000} = \$3.23.$$


POWER PLANT OPERATING LOG

STATE HOSPITAL, RALEIGH, N. C. DATE:

COAL | ASH | STEAM | GENERATING | HEATING | REFRIGERATION | BOILERS

Fig. 2—Daily power plant log

As the freight rate on high-volatile coal to this plant is $3.10 per ton, the mines could be paid only $0.13 per ton for that coal. This, of course, entirely eliminates it as a competitive brand of coal.

The cost per 1,000 lb. of steam is the whole group of variables in coal selection reduced to its final analysis. It is hard to understand why any plant equipped with the necessary metering instruments does not use this method for the purchase of coal.

Next in importance to proper selection of coal is economical distribution and utilization of steam generated. Here the engineer must first enlist the co-operation of every department he serves, and in many cases must tactfully educate those in charge of these departments as to the correct and economical use of the steam served to them. This is mostly true for process work, as

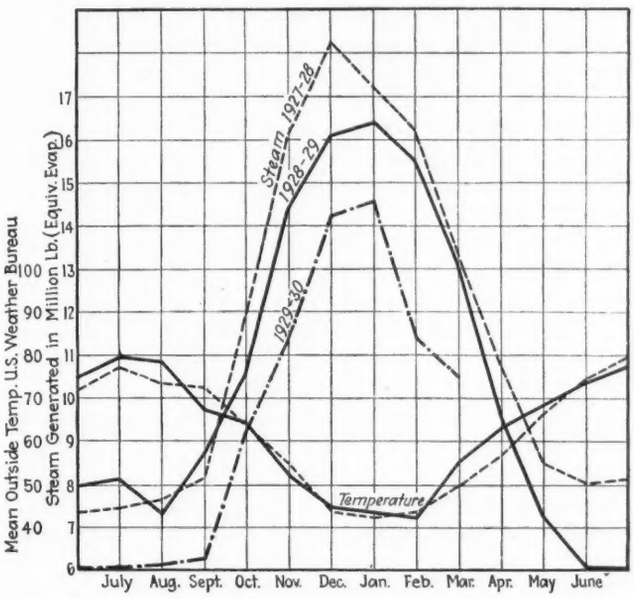

Mean Outside Temp. U.S. Weather Bureau
Steam Generated in Million Lb. (Equiv. Evap.)
Steam 1927-28
1928-29
1929-30
Temperature
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June

Fig. 3—Comparison of monthly steam consumption

heating comes more directly under the supervision of the engineer for all the departments.

Practically all heating systems today have one vital fault, and that is a lack of means for modulation. Until recently little refinement or development had taken place since heating systems first came into use. Thermostatic controls of various designs are now on the market, but their drawbacks appear to be high first cost and maintenance.

The orifice system of steam heating which is now coming into more general use has many advantages that are not generally known. The initial cost of the valve is practically the same as that of ordinary radiator valves, the distribution of steam to each part of the heating system is more nearly perfect, its use is "foolproof," and maintenance is low, as there are no working parts to wear or give trouble except perhaps in the pressure control mechanism.

To supplement modulation there should be a central control for the supply mains that is convenient and as close as possible to the point of generation. This prevents overheating in extremely mild weather and also prevents heating at times when it is not needed. Not only does a great economic loss result from overheating, but without doubt there is more harm done to the physical condition of the occupants of a building by overheating than by underheating. Often, steam heating is blamed for the easily contracted colds or decreased body resistance to outside temperature.

Many extensive heating systems have sections that overheat or underheat, it matters not how carefully the designing has been carried out. Correcting these high and low sections is nearly always left to the operating engineer, as they are usually not discovered until the first heating season is in full swing and the contractor has been paid for the job.

In one instance we had a large open dormitory room utilizing about 800 sq.ft. of radiation, which could not be heated comfortably except by overheating the entire building served by the same reducing valve. At first it seemed as though it would be necessary to install additional radiation, but by applying a coat of white zinc paint over the aluminum bronze paint the heat emission of the radiators already installed was increased sufficiently to give satisfactory results. Most test data show that a surface of white zinc paint will emit about 25 per cent more heat than aluminum, gold or bronze surface.

Another difficult thing to handle properly is ventilation. No set rule can be made for the proper number of air changes that should take place in a room per hour, for they must vary with the number of occupants in the room and the work that is being carried on. However, one air change per hour is sufficient for average practice. It is shamefully wasteful to open wide doors or windows to the outside atmosphere and then expect the room to be kept at a comfortable temperature.

If coal is to be selected properly and steam used economically, records must be kept not only as a further incentive for greater economy, but to serve as an eye through which the engineer sees the plant. Such records should be in simple, understandable form for those outside the plant, and should always be comparative. Records are a form of publicity for the engineer, for it is the only way that his immediate superior may correctly gage his efficiency. It makes no difference how well he knows his own efficiency, it must be known by others to be of any material value to him.

A daily log sheet should be provided from which a systematic and constant supply of data is available. The

ENGINEER'S REPORT

	July, 1928	July, 1929	Decrease	Increase
Total steam used, lb.	8,150,000	6,000,000	2,150,000	.....
Coal consumed, lb.	742,913	556,715	186,198	.....
Steam per lb. of coal	10.98	10.78	.20	.....
Over-all boiler efficiency, per cent	73.5	74.6	.....	1.1
Cost of fuel per 1,000 lb. of steam, cents	20.1	16.7	3.4	.....
Steam used in engines, lb.	2,807,500[1]	3,301,900	.....	494,400
Kw.-hr. generated	56,150	70,880	.....	14,730
Steam per kw.-hr.	50[1]	46.6	3.4	.....
Estimated exhaust used, per cent	50	65	.....	15[2]
Cost of current, cents per kw.-hr.	1.6	1.0	.6	.....
Ice delivered, lb.	.....	200,000	.....	.....
Domestic water used, lb.	10,950,000	9,800,000	1,150,000	.....
Total cost of fuel for month	$1,650	$1,000	$650	.....

[1] Estimated.
[2] Betterment increases.

log sheet should cover both the boiler and engine rooms for the average small plant, and should record every possible detail of operation that can be definitely determined. A form used in the state hospital is shown in Fig. 2.

These logs are worked up, filed daily, and at the end of each month the total quantities are determined. This record may be kept in the form of a report submitted to the superintendent or president of the institution. He is then correctly informed as to the operation of this particular department. The engineer's report shows a comparative record of the previous year, and it is obvious that any report made without this comparison would mean little to a man unfamiliar with power plant operation. All details and unnecessary data should be eliminated. These monthly reports should then be compiled into yearly reports, and the monthly data plotted so that the year's operation can be easily visualized.

It will be noticed in the engineer's report that for July, 1928, the steam per pound of coal was 0.2 lb. more than for July, 1929, although the boiler efficiency shows an increase of 1.1 per cent. This is because a low-grade 13,500-B.t.u. coal was used in 1929, against a 14,500-B.t.u. coal in 1928. The steam per kilowatt-hour was reduced by decreasing the back pressure on the engines,

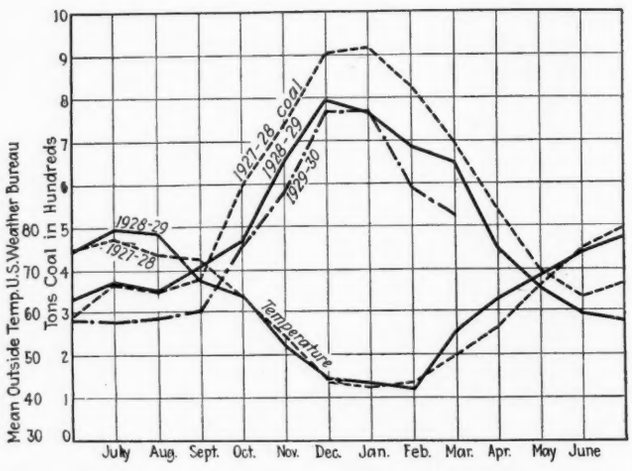


Fig. 4—Comparison of monthly coal consumption

which, in turn, lowered the cost of current. The latter includes interest on capital invested, depreciation, operators' time, cost of steam chargeable to the engine, including all exhaust wasted to atmosphere (35 per cent for this month), and miscellaneous charges. This plant is producing current for around three-quarters of a cent per kilowatt-hour during winter months when no exhaust steam is wasted.

The reduction in engine exhaust pressure was secured by installing water-operated ejectors on two water heaters that used exhaust steam. The heaters are some distance from the engine, and exhaust pressure of 7 lb. had been necessary. The vacuum created by the ejectors made it possible to supply steam to these heaters with an exhaust pressure of only 1 lb. The water used in the jets of the ejectors is discharged to the receiving tanks of the heating system, and is utilized as part of the boiler make-up.

Figs. 3 and 4 show curves of coal and steam consumption for the North Carolina State Hospital power and heating plant at Raleigh. They have served not only as an incentive for greater economy by the operating force, but also have centered the attention of the superintendent and officers of the institution on the facts and results of economical power plant operation. By the end of the present fiscal year the annual fuel bill for the institution will have been decreased about $11,000, a reduction of 35 per cent of the 1927 costs.

The Effect of Altitude on Power Equipment

There are four types of power-producing machinery in commercial use today—Steam, Diesel, gas or gasoline engines, and electric motors. What, if any, effect has altitude on their power and efficiency characteristics? The author's conclusions may upset readers' prior beliefs

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IT MAKES a difference whether a steam plant is operating condensing or non-condensing as to the effect of altitude. For steam machinery operating non-condensing, the influence of altitude may be considerable. Take for example a reciprocating engine operating with atmospheric exhaust, and supplied with steam at 150-lb. gage pressure.

The horsepower can be found by the formula

$$Hp. = \frac{PLAN}{33{,}000} \qquad (1)$$

When P = Mean effective pressure in pounds per square inch.
L = Length of stroke in feet.
A = Piston area in square inches.
N = Working strokes per minute.

The mean effective pressure P equals the mean forward pressure minus the mean back pressure, or

P = (initial pressure)

$$\left[Z + (Z + c)\left(\log_e \frac{1 + c}{Z + c}\right)\right] -$$

(back pressure) $(1 - X) + (X + c) \log_e \frac{X + c}{c}\Big)\Big]$

when Z = cutoff
c = clearance
and X = compression.

Mean forward pressure is a function of initial pressure, in terms of absolute pressure, and of cutoff. For a given initial pressure and cutoff it remains constant, and as it is assumed that the steam conditions remain the same at the higher altitude the mean forward pressure is constant. On the other hand, mean back pressure, while modified slightly by compression, in normal engines depends almost entirely upon the atmospheric pressure against which the engine is exhausting.

The limiting condition is, of course, that for complete expansion, which is also the case of the properly designed steam turbine. With such a turbine, operating at sea level with atmospheric exhaust and with an initial pressure of 150 lb. gage, available work per pound of steam will be 136,100 ft.-lb., while for the same machine operating at 10,000 ft. altitude, when the back pressure of the atmosphere is about 10.5 lb. per square inch, there will be available per pound of steam 151,600 ft.-lb. of work, a difference of 15,500 ft.-lb. per pound of steam, which is 11.4 per cent better than the sea-level condition. In other words, the capacity increases with altitude.

When the engine or turbine is operated condensing, however, conditions change somewhat.

Modern steam machinery operates on the Rankine cycle, the efficiency of which is expressed by the equation

$$E = \frac{H_1 - H_2}{H_1 - h_f}$$

Where H_1 = Total heat of the steam in B.t.u. above 32 deg. F. as admitted.
H_2 = Total heat of the exhaust steam in B.t.u. above 32 deg. F.
h_f = Heat of the condensate in B.t.u. above 32 deg. F.

It is well known that at a high altitude the vacuum that can be maintained on a condenser is lower than at sea level. This has often given rise to the idea that because the vacuum is lower, the efficiency must also be lower.

However, power and efficiency depend not upon gage pressures and vacuum but upon total heats, which are, in turn, functions of absolute pressures and temperatures. Therefore, for an altitude where the standard barometer is 28 in. of mercury, a 27-in. vacuum is just as good and the machine is just as efficient as if the barometer were 30 in. and the vacuum 29 inch.

In other words, the absolute pressure in both cases is 1 in. of mercury (or about ½ lb. per sq.in.), and the heat in the steam depends upon the absolute pressure.

In this connection it is interesting to note that the change in total heat of the steam in a turbine, for instance, from 1 to 2 lb. abs. is about the same as that from 215 to 150 lb. abs. This indicates clearly the

enormous importance, not of a high vacuum, irrespective of atmospheric conditions, but of a low absolute pressure in the condenser.

The effect of altitude upon internal-combustion engines is very serious.

Let us consider first the Otto-cycle gas or gasoline engine. Other things being equal, the power of a gasoline engine is a function of the weight of charge, or mixture, per working stroke. The indicated horsepower is obtained from the same equation as for a steam engine, but the mean effective pressure, P in this case, is a function of the heat added per cycle. This, in turn, depends upon the charge weight per cycle, assuming that the engine is being supplied with a proper mixture of fuel and air. Now, since a pound of air contains enough oxygen to burn about one-fifteenth of a pound of gasoline, this means that the lower the weight of air per cubic foot, the less gasoline per cylinder volume of mixture, and the less heat added per working cycle, or less power from the engine.

A cubic foot of air at sea level and 32 deg. F. weighs 0.0807 lb., and at 10,000 ft. altitude and the same temperature weighs 0.056 lb., or 69.4 per cent as much. Since the percentage of oxygen in air is constant regardless of altitude, and fuel must have oxygen in order to burn, if the density of the air is reduced by 30 per cent, the amount of fuel that can be burned per unit volume is also reduced 30 per cent, as is the power output of the engine.

The relation of air density to altitude is shown in Fig. 1, and in Fig. 2 the per cent variation in power for internal-combustion engines from sea level to 10,000 feet.

Altitude has no effect upon the indicated efficiency of an Otto-cycle engine. This can be seen from the equation for efficiency:

$$E = 1 - R_v^{0.4},$$

where R_v = the compression volume ratio.

Indicated efficiency, however constant, is not, unfortunately, of much value when over-all efficiencies vary, since it is the latter, or "brake" efficiency, that determines profits or losses.

It is a well-known fact that the internal friction of any internal-combustion engine is a definite and constant quantity, depending not at all upon the per cent of load at which the engine is operated, but solely upon its type and size.

This internal friction may be, and should be, expressed in terms of the mean effective pressure required to overcome it. Dr. Charles E. Lucke, in a paper on "Large Oil Engines" gave it a value of ± 17 lb. per square inch for four-cycle, single-acting, trunk-piston engines.

Therefore, if, due to altitude conditions, the indicated mean effective pressure of an engine is reduced, and the friction mean effective pressure remains constant, the brake mean effective pressure, which is the difference of the two, is also reduced and so likewise is the brake, or over-all, efficiency.

The same conditions obtain in a Diesel engine as in a gasoline engine. Its power is also derived from burning fuel in the cylinder; in this case, however, at constant, or nearly constant, pressure. If the amount of air, and hence the amount of oxygen, is cut down, due to a decrease in density, the amount of oil that can be burned per cycle will be reduced in direct proportion, and the available power will again be less by the ratio of the air density at operating conditions to that at sea level.

Just as for the gasoline engine, the friction mean effective pressure will remain constant regardless of per cent load or altitude, and, therefore, a similar effect will be observed on the over-all efficiency.

The question may arise as to the effect of lower air densities upon the temperature of the air charge at the end of compression. Since a Diesel engine has no ignition apparatus as such, it depends entirely for ignition of its fuel upon the temperature rise of the air charge due to compression. As the temperature due to compression is a function of the pressure ratio rather than of the pressures themselves, the temperature conditions are not affected at all.

Compression in a Diesel engine follows the adiabatic law, that is, the temperature ratio,

$$R_T = R_V^{0.4} = R_P^{0.286}.$$

For example, let us assume an engine with a compression pressure of 500 lb. gage, or 514.7 lb. abs., at sea level: R_P is then $514.7 \div 14.7$, or 35, and R_T, the temperature ratio, is $35^{0.286}$, or 2.76.

If the temperature at the beginning of compression is equal to atmospheric temperature, or 60 deg. F. plus

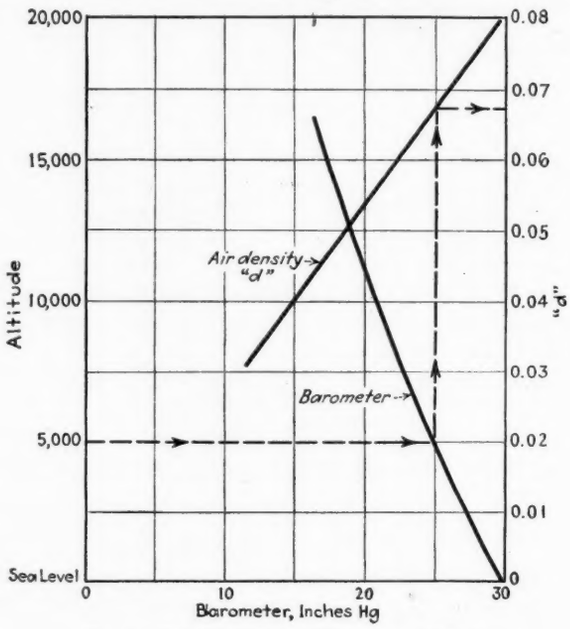


Fig. 1—Relation of air density to altitude

suction heating, of about 100 deg., the absolute temperature at the beginning of compression will be 620 deg. F. abs. And temperature at the end of compression will be $620 \times 2.76 = 1{,}710$ deg. F. abs., or $1{,}710 - 460 = 1{,}250$ deg. F.

The same engine at 5,000 ft. altitude, with the compression volume ratio R_v remaining the same, the temperature ratio will still be 2.76, regardless of the pressure at the beginning of compression, and, therefore, the engine will, so far as insurance of satisfactory ignition temperature is concerned, operate as at sea level.

Electric motors and generators are also somewhat affected by high altitudes. As is well known, the power of an electric motor is determined by its voltage and current flow and its efficiency. It seems odd at first glance that a condition of atmospheric density could affect its power output. But, when it is considered that whenever an electric current flows there is a heating effect equal to the square of the current in amperes multiplied by the resistance in ohms, or I^2R, the reason will become clear.

Since there is a heating effect, there must also be a

means for removing the heat, else the machine would overheat and eventually destroy itself. This heat removal is accomplished by air circulation within the machine, and is expressed as:

$$H = WC_P(T_2 - T_1).$$

Where W = Weight of cooling medium in pounds (in this case air).

C_P = The specific heat of air at constant pressure.

H = Heat removal in B.t.u.

$(T_2 - T_1)$ = The temperature rise of the air in deg. F.

It is seen that the heat transferred from the motor to the cooling medium is a function of the mass flow of the medium.

Since at high altitudes a cubic foot of air will weigh considerably less than at sea level, it is apparent that a considerably greater volume of air must be circulated through the machine in order that the temperature may be maintained within the operating range.

A motor or generator which at sea level may easily

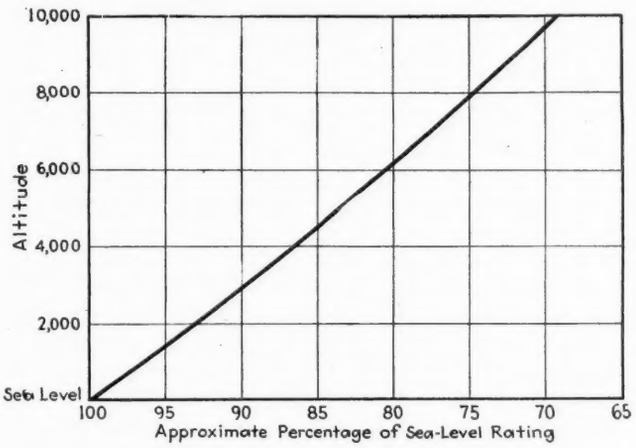


Fig. 2—Effect of elevation on an internal-combustion engine

carry its rated load may, and probably will, give considerable trouble at high altitudes due to overheating, unless care is taken to correct the difficulty.

It has been shown that for the four methods of producing usable power three of them are definitely handicapped at high levels.

What, if anything, can be done about it?

There are two ways of dealing with all three types of machine, and while both cost money one costs much more than the other.

The first, and most expensive, is to use a machine of such rating at sea level that, due to its oversize, the power at altitude will be the desired amount.

The second, and less expensive, is to use, for an internal-combustion engine, a supercharger to supply the sea-level weight of air, and for electric machinery a blower or high-pressure fan for the same reason.

The writer believes that of the two methods the second is the more logical. Since the cost of any power machine is figured in dollars per rated horsepower or kilowatt, and the machine is always rated at sea-level conditions, the reason becomes evident. It becomes still more evident when it is noted that for a given type of machine the cost can be figured in dollars per pound of weight. If horsepower varies inversely with altitude, dollars per pound varies directly with altitude, and for a large plant the increase may be a considerable portion of the whole outlay.

On the other hand, the cost of blowers or superchargers, while significant, should not be high, nor should the power required to operate them be such as to increase the plant size to any appreciable extent.

It has been shown that the power and efficiency of a steam engine or turbine are not adversely affected by altitude. On the other hand, the boiler plant is very definitely affected, since a pound of fuel, whether coal or oil, requires a definite weight of air for complete combustion in a boiler, exactly as it does in an engine. A high-altitude boiler plant, then, will require considerably more blower capacity than will one at sea level.

Let us assume a boiler plant burning normally ten tons of coal per hour. Ten tons is 20,000 lb., and if 1 lb. of coal requires about 15 lb. of air, there will be required per hour $20{,}000 \times 15 = 300{,}000$ lb. of air, or 5,000 lb. a minute. At sea level and normal temperatures, a pound of air occupies about 13 cu.ft., so sea-level air requirements for the plant would be $13 \times 5{,}000 = 65{,}000$ cu.ft. of air a minute.

At 5,000 ft., however, a pound of air occupies about 15 cu.ft., so the blower capacity in cubic feet per minute will be increased in the ratio of 15 to 13, or 1.15—15 per cent, not an excessive amount. It should be noted at this point that this 15 per cent is merely the increase in blower horsepower, which, for the quantities of air under consideration, should be somewhat less than 50.

A plant burning ten tons of coal an hour would develop, roughly, about 10,000 kw.; therefore, the increase in blower power could not even be found in the cost sheet. But it should be in the specifications.

Let us now see what would be necessary in the case of a Diesel engine for a power house at 5,000 ft. altitude. Assuming a pair of 1,000-hp. engines, how much blower capacity would be required to use engines of 1,000-hp. sea-level rating?

A good Diesel engine of this size should develop 1 hp. on 0.45 lb. of fuel, which means that each engine will require $0.45 \times 1{,}000 = 450$ lb. of fuel per hour.

If 1 lb. of oil requires 15 lb. of air for complete combustion, and since commercial practice will allow about 100 per cent excess air for conservatively rated Diesel engines, there will be required by each engine per hour $1{,}000 \times 0.45 \times 15 \times 2 = 13{,}500$ lb. of air per hour. And if each pound of air occupies 15 cu.ft., the volume per hour will be 202,500 cu.ft., or 3,375 cu.ft. a minute.

It will be necessary to raise this air approximately $2\frac{1}{2}$ lb. in pressure, requiring about 31 air-horsepower. If a turbine-blower is used, 70 per cent efficiency may be expected; so the horsepower required by the blower will be $31 \div 0.70 = 44.5$, approximately, or about $4\frac{1}{2}$ per cent of the engine output.

This becomes more significant if we consider the size of engine required to give the same power without supercharging.

The ratio of density of air at 5,000 ft. and at sea level is $0.0675 \div 0.0807 = 0.835$.

If we consider that the power of an engine will vary directly with air density, we see that to obtain 1,000 hp. at 5,000 ft. altitude it will be necessary to have an engine with a sea-level rating of $\frac{1{,}000}{0.835} = 1{,}200$ horsepower.

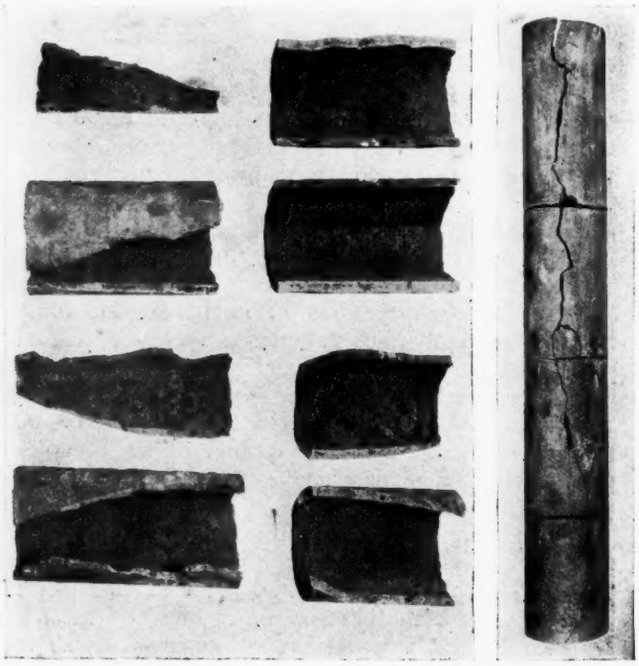
It will take considerable blower installation to cost as much as 200 extra horsepower in the engine, even without figuring the extra losses of the larger engine over the supercharged unit.

. . . RIGHT OUT OF THE PLANT . . .

Failure on Cast Iron Boiler Feed Line

IN FEBRUARY, 1923, the equipment in our heating plant was put in service. The plant then consisted of four 6,120-sq.ft. water-tube boilers operating at 225 lb. gage pressure with stokers burning No. 3 buckwheat coal. The boiler-feed lines are cast iron, designed for a working pressure of 250 lb. tested to 425 lb. Feed-water pumps are turbine driven, three-stage centrifugals, and each boiler is fitted with a feed-water regulator.

Until recently there had never been any trouble with the feed-line. One evening last March after the load was cut and only two boilers were in service, operating at about 125 per cent rating, the 5-in. cast-iron feed line back of No. 2 boiler developed a crack, as shown in



Section of fractured pipe opened up shows blow holes and unequal wall thickness

the view at the right of the illustration. The chisel marks shown were made in opening up the pipe for examination.

The section of the pipe affected was found to be well filled with blow holes between the inner and outer surfaces, and to be of unequal section.

The break caused temporary complete shutdown of the plant until the boiler feed could be shifted to the auxiliary line. Had the break occurred when the four boilers were operating at 200 per cent of rating, it might have caused serious damage to some of the boilers.

Ithaca, N. Y. C. E. CURTIS.

Filing Clippings and Technical Data

WHETHER engaged in engineering or in a less specialized field, one who would keep abreast of the times must read the literature of his chosen profession. Merely to skim the many available publications and take mental note of the numerous articles, illustrations, etc., in which he has, or may have an interest, is no light task.

Most branches of engineering have a more or less specialized current literature regularly published in at least one, and often in several, weekly or monthly magazine. The bulk represented by a year's accumulation of the various periodicals, or even of a single weekly or monthly technical magazine, is disconcerting to one who has small space to devote to their storage. A simple and convenient method of clipping, filing, and indexing these many articles, etc., is a need for every person who must have his data at his finger tips and has not already adopted such a method. Probably not over 5 to 10 per cent of the bulk of the average technical periodical will be found to have permanent value to the person whose field of endeavor has been well defined. Efficiency and economy of space, as well as speed and ease of consultation, therefore, demand that articles, etc., be clipped, the sheets of a given paper securely fastened together, and then neatly and correctly filed away.

I have used a simple system for several years with satisfactory results. It has the virtue of elasticity, so that any subject may be further subdivided when the material becomes too bulky or it becomes desirable for other reasons. It was expanded somewhat from a system previously devised and used by Charles O. Tappan, consulting engineer, New York City.

Matter is filed in numbered envelopes, file pockets, or folders, as one may desire, in vertical file drawers. Each

BYRON E. WHITE ENGINEER UTICA N. Y.	File No.

subject is assigned a number, which is prominently marked in red pencil on the upper right-hand corner of the first page or cover of the article, in the blank space of a rubber-stamped imprint, similar to the one illus-

TABLE I—INDEX TO TECHNICAL LITERATURE, DATA, ETC.

1-150	Hydraulic Engineering—Hydro Plants
151-200	Steam Engineering—Steam Plants
201-300	Electrical Engineering
301-340	Gas Engineering—Plants, etc.
341-350	Oil Engineering
351-425	Structural Engineering—Architecture
426-500	Mechanical Engineering
501-525	Construction Methods and Equipment
526-540	Mining Engineering and Metallurgical
541-575	Sanitary Engineering—Water Supply
576-600	Transportation—Railroads—Automobile—Marine
601-620	Highway Engineering
621-640	Irrigation and Drainage Engineering
641-675	Industrial Plants and Processes—Miscellaneous
676-700	Automotive Engineering—Aviation
701-725	Chemical Engineering—Chemistry
726-750	Drafting—Reproduction—Photography—Office Practice
751-775	Surveying—Mapping
776-785	Agriculture—Horticulture
786-800	Forestry—Forest Products
801-810	Mathematics
811-825	Science—General
826-850	State and Federal Governments—Developments, etc.
851-860	Engineering Societies
861-865	Accounting—Cost Keeping
866-870	Purchasing and Selling—Stock Keeping
871-875	Rates—Rate Making—Billing
876-900	Legal—Rights-of-Way, etc.
901-905	Taxation and Assessment
906-910	Valuation and Appraisal
911-920	Capitalization—Stocks—Bonds—Notes
921-930	General Maps
931-950	Utica Gas & Electric Co. System—Plants, etc.
951	Public Relations
952	Labor—Problems—Relations
953	Advertising
954	Economics
955	Engineering—Engineers
956-960	Psychology—Social Science
961-975	Statistics—General
976	Reports
997	Safety—Safety Engineering—Accident Prevention
998	Municipal Engineering—City Planning
999	Consulting Practice—Fees, etc.
1000	Indexes to Periodicals

trated herewith. The name and address of the owner is a more or less potent reminder of ownership, to the person to whom a clipping has been loaned with the promise of ultimate return. One might even "spot" it on the other fellow's desk and reclaim it!

The subject of interest under which a given article may be filed may be different from anything suggested in the title, as, for example, a novel form of spillway gate, illustrated in connection with the description of a hydro-electric plant. In case there are other details in the particular article which it is desired to find later, a blank sheet of paper of letter size (8½x11 in.) is stamped and marked with the file number of the appropriate subject, and the subject, as well as the title of the original article, the name and date of the periodical in which it appeared, and a reference to the file number under which the original article was filed. Another sheet is similarly made for each additional subject contained in the article desired to index.

The index is, of course, the most important detail. It may be prepared on index cards, in a loose-leaf, or in a bound book. I find a book of loose leaves, fastened with paper fasteners in a substantial cover, best suits my requirements. The semi-permanent fastening is insurance against the inadvertent removal of a sheet, while it permits a sheet to be readily removed and revised or retyped, or new sheets to be added.

In laying out the index, subjects approximately alike should be grouped as near together as possible. This saves needless time hunting through the index for a given subject. I first decided that the numbers 1 to 1,000 would be sufficient for my purpose. The major divisions of engineering, science, etc., were then assigned certain groups of numbers, as shown in Table I. Following this, each major division was subdivided into individual subjects, as in Table II.

A liberal quota of unused numbers should be allowed under each main division when preparing the index. The Dewey system of index numbers represents the ultimate possible expansion. Something similar, but simpler, may be accomplished by assigning decimal numbers or letters, following the primary index numbers previously selected, in order to subdivide a subject. For example, "49—Spillway Gates" might be subdivided into:

49.0 or 49-A—Spillway Gates, General
49.1 or 49-B—Taintor Gates
49.2 or 49-C—Stoney Gates, etc.

File numbers must, of course, be assigned by one who is familiar with the subject. When once marked, the filing and finding is so simple that it may be handled with minimum chances of error. One can have the assurance that all the material filed under the subject is at hand, unless it may have been filed under a closely related or analogous subject, in which case the index should be cross referenced. For example, "55—Canals, see 94—Barge Canal," and vice versa.

When a new subject comes to one's attention, its title is written opposite a blank number in the proper major group, as near as possible to related subjects. The index is thus capable of indefinite expansion. If the file numbers are marked on the papers in pencil, instead of ink, the whole scheme can be rearranged, if desired, the numbers erased, and new numbers written in.

This method is adaptable to the filing of clippings, pamphlets, blueprints, photographs, and all kinds of data. Unless the volume of material accumulated under a single heading or number becomes inordinately bulky, the introduction of decimal numbers or sub-letters will ordinarily be more troublesome than helpful. These may be employed, however, to identify particular documents

TABLE II—SUBDIVISION OF INDIVIDUAL SUBJECTS

40	Dams—Gravity Masonry—Design—Details—Ice Thrust
41	Dams—Arched Masonry—Design—Details
42	Dams—Reinforced Concrete—Design—Details
43	Dams—Multiple Arch—Design—Details—Domes
44	Dams—Earth and Core Wall—Design—Details
45	Dams—Hydraulic Fill—Design—Details
46	Dams—Rock Fill—Design—Details
47	Dams—Movable—Design—Details
48	Dams—Timber and Crib—Design—Details
49	Dams—Flashboards and Movable Crests—Design—Details—Spillways
50	Dams—Coffer Dams—Sheet Piling—Temporary Dams—Check Dams—Design—Details
51	Dams—Foundation—Investigations—Pressure Grouting—Water Proofing—Erosion (See 360)
52	Dams—Racks and Appurtenances—Head Gates—Hoists—Stop Logs—Gate Houses—Intakes—Outlet Works—Log Chutes—Fishways (See 21)
53	Dams—General
54	Siphon Spillways
55	Canals and Ditches—Linings
56	Flumes and Outlets
57	Wood Stave Pipe and Accessories
58	Steel Pipe and Accessories—Pipe Line Design
59	Reinforced Concrete Pipe and Accessories

of importance, or which are frequently wanted. The whole object is to reduce the time and labor of filing to a minimum in cases where it is not deemed essential to give an identifying number to each and every accession. Where the latter is considered necessary, the Dewey or some similar system must be adopted.

It is particularly adapted to the needs of the individual engineer or the small office, where the volume of such papers is not too large and there is no great objection to searching through a file ranging from a few to perhaps fifty clippings for the one desired. This is often a great advantage, in that forgotten articles of interest and value come to light during the search. The value of this plan is equally great for the filing of papers relating to any subject other than engineering; in fact, it is almost universal in its application to the needs of business and professional men, writers, etc. A carefully thought-out and comprehensive index and proper filing receptacles are the prime requisites.

BYRON E. WHITE,
Utica, N. Y. General Engineering.

Electric Heat Used in Cold Storage Rooms

A NOVEL use for electric strip heaters has been made in the cold-storage room of the Hennesy Brothers plant at Helena, Mont. It is so cold in Helena in winter that the refrigerating machine used to cool the meat storage room may not run for several days at a time. When the machine does not run for a reasonable portion of each 24 hr., there is not sufficient circulation of air to prevent the meat from spoiling. The problem was to provide some way to cause the machine to operate

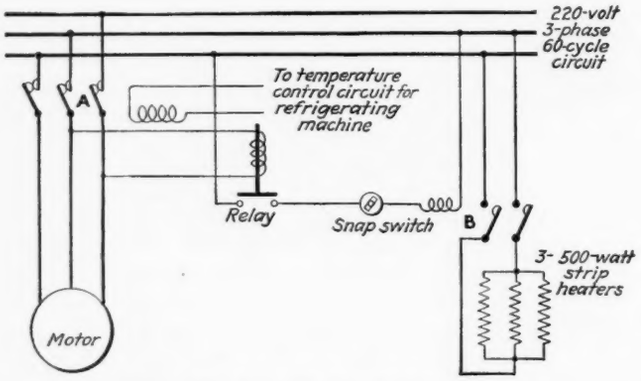


Diagram of motor and strip-heater connections

a reasonable portion of the time. To remedy the situation, the York Ice Machine Corporation installed three 500-watt strip heaters, which are put on the line by a magnetic switch controlled from outside the cold room by a snap switch. To save power a normally closed relay opens the coil circuit of the magnetic switch when the motor is running. This arrangement prevents the strip heaters' being in use when the refrigerating machine is operating.

S. J. KESTER,
Denver, Colo. General Electric Co.

Evaporator Used as Reducing Valve

REFERRING to the question in the April 1 number regarding a means of utilizing steam at 300 lb. gage and 100 deg. superheat for uniflow steam engines designed for a working pressure of 150 lb. gage, I should like to offer the following suggestions:

One or more bent-tube evaporators of the reducing-valve type may be used to considerable advantage if the following conditions are those of the proposed installations:

1. If the uniflow steam engines exhaust to jet or barometric condensers and the steam supplied to these units is not recoverable.

2. If the boiler feed water has scale-forming characteristics and considerable boiler and heat transfer troubles have arisen because of scale formation.

The advantages of bent-tube evaporators of the scale-shedding design, removable tube-bundle pattern, when used in place of reducing valves, are as follows:

1. An evaporator, when controlled by a suitable regulating valve, will maintain a constant discharge vapor pressure.

2. The steam used to operate the evaporator (steam-fired boiler) to produce lower pressure steam from the evaporation of raw water carried at a predetermined level in the shell can be returned to the boiler in the form of condensate.

3. The scale formation likely to take place is on a bowed-tube surface having the characteristic of scale-shedding by the thermal-cracking process.

4. Evaporators are 100 per cent thermally efficient, except for minor radiation losses and during the periodic scale-cracking interval.

5. Evaporators may be designed to produce a certain excess amount of vapor above that required for the uniflow steam engines, this excess being condensed in an auxiliary condenser using evaporator feed as circulating water, and the required amount of low-pressure steam condensed may be returned to the steam in the form of condensate to be used as boiler feed-water make-up.

The arrangement as outlined in the foregoing will allow high-pressure boilers the advantage of operating on distilled water, thus reducing boiler maintenance and at the same time improving heat transfer.

New York City. R. W. MUNRO, *Engineer,*
Griscom-Russell Company.

Welding Head Cracks

I HAVE just finished reading the different opinions as to welding a crack in the rivet joint of a head, appearing in *Power,* May 6. None suggested the proper thing: a crowfoot brace from the head to the shell opposite the crack. Then the crack could be filled with solder, or even red lead and oil, and the brace would support the load. I did not mention this in my reply for fear of putting a bad idea in the head of some young engineer.

When I look back over 35 years' experience with steam plants, I marvel that some of us live to tell the tale. The chances we used to take would give a new man the creeps; for instance, carrying 210 lb. of steam on standard pipe and 565 lb. water pressure on standard pipe with extra-heavy fittings only in the lower half of the mine shaft. We operated old boilers at 100 lb. when we did not dare have them examined, and yet, even ten years later some of them were still going strong.

In my young days we would have considered water with 11 grains of solids, "soft." Most of our well water in Illinois and Missouri carried 50 or more grains, and I operated with Arizona water carrying 268 grains, but I softened it with lime and soda ash.

Cleveland, Ohio. L. R. BAKER,
The National Acme Co.

✦

REFERRING to answers given to the question of welding a crack in the head of a drum of a water-tube boiler in the May 6 number, it appears that one salient factor has been overlooked.

In welding it often occurs that the area immediately subtending the weld becomes brittle, thus reducing the efficiency of such plates anywhere from 10 to 40 per cent, although I have seen welds show an efficiency of 92 per cent. This efficiency, of course, depends upon the manner in which the weld was made; if the "V" cut was properly cleaned and filled with the welding rod. The better the weld the higher the efficiency. However, having no mechanical means to determine the efficiency of such weld, the minimum efficiency must be assumed to apply thereto. S. ROSENBERG, *Inspector.*

Panama Canal.

Semi-Annual A.S.M.E. Meeting in Detroit

Marked by Valuable Power Papers

Properties of metals at elevated temperatures, boiler feed water, tests of boiler shells, the burning of wood refuse, recovery of fly ash, comparative tests of oil and gas firing, and comparative performance of bin and unit pulverized coal systems, included among subjects

A VARIED PROGRAM, dominated by papers on power or allied subjects well repaid those who attended the semi-annual meeting of the American Society of Mechanical Engineers at Detroit last week. In addition to the technical program and usual social events, Detroit afforded an exceptional opportunity for making a number of most interesting inspection trips. The attendance numbered 630.

Following the customary practice at semi-annual meetings the nominating committee reported its slate for next year's officers. Roy V. Wright, managing editor of *Railway Age*, was nominated for the office of president.

William A. Hanley, chief engineer, Eli Lilly & Company; Thomas R. Weymouth, president, Oklahoma Natural Gas Corporation; and Harvey N. Davis, president of Stevens Institute of Technology, were nominated for vice-presidents.

The slate for managers comprised W. L. Batt, president, S K F Industries, Inc.; H. L. Doolittle, chief designing engineer, Southern California Edison Company; and H. L. Whittmore, chief of the Engineering Mechanics Section, Bureau of Standards.

Fatigue Tests of Boiler Shells

Results of comparative tests of resistance to repeated pressure on forged, riveted, and welded boiler shells were reported by Prof. H. F. Moore, of the University of Illinois. These tests had been conducted at the Barberton Works of the Babcock & Wilcox Company and included a standard A.S.M.E. riveted drum, a manganese-steel riveted drum, a forged seamless-steel shell, two forge-and-hammer-welded shells and eight fusion-welded (metallic-arc) shells.

The test pressure in most cases was alternated between zero and that corresponding to 50 per cent more than the maximum allowable working pressure given by the A.S.M.E. code. In some cases it was carried higher. The number of cycles of pressure application varied from as low as 5,530, in the case of one of the arc-welded shells that failed, to 1,995,450, in the case of another arc-welded shell that did not fail. A summary of the test results is given in the table.

All the arc-welded test shells were strain-annealed at 1,200 deg. F. previous to testing.

The effect of local defects other than those inherent in the welds is emphasized by the failure of a number of test shells at the tapped hole for a gage connection. The tests indicate that wide variations in fatigue strength will result from different types of welding; also that properly made arc-welded joints have greater resistance to repeated stress than the plates themselves, when the latter are weakened by small holes or surface defects.

In the discussion of Professor Moore's paper, it was pointed out that the characteristics of the welding metal must be similar to those of the plate and that tube holes should not pass through reinforcing straps. The importance of the stresses set up in rolling was also mentioned. The effect of large tube holes is now under investigation, it was stated.

A. E. White and R. Schneidewind, both of the University of Michigan, presented the results of some studies of boiler metal failures such as fractured tubes, blow-off pads, saddles, plates and rivets. The investigations were largely of a metallographic nature, and the authors showed a large number of photomicrographs. These indicated that bending, compression, tension, and impact all produce fractures that are predominantly through the grain, with failure accompanied by a deformation of the crystals. Fatigue cracks are always transcrystalline, without deformation of the grain. Caustic enbrittlement, as found in metal which has been in service in alkaline liquids, produces intercrystalline cracks.

Many failures were traced to strains indicated by careless riveting. Sharply bent flanges, if not properly heat-treated, are likely to suffer from aging and become brittle, or they are apt to fail by corrosion.

A large number of failures occur from defects which, although they may have their inception in the stresses or flaws present when the boiler went into service, do not make their appearance until after the boiler has been in service for some time. Cracking sometimes occurs in stressed parts due to blue brittleness. That is, if a piece of low-carbon steel is

SUMMARY OF TEST RESULTS

Specimen	Shell Dimensions — Inside Diam., In.	Plate Thickness, In.	Longitudinal Seams	Efficiency of Joint, Per Cent	Max. Allowable Working Pressure, Lb. per Sq. In.[1]	Range of Test Pressure, Lb. per Sq. In.	Range of Tensile Hoop Stress	No. of Cycles of Pressure Applied During Test	Remarks
Manganese-steel test drum, riveted	35⅜	1.0	2 at 180°	71	638	0–1260	0–31,500	130,225	Crack in drum head below manhole
A.S.M.E. standard riveted drum	42	2.0	One	80	838	0–1260	0–16,500	1,013,840	No fracture
Forged test steel	42	1¼	None	100	1047	0–1570	0–18,000	446,950	Failed at ¼-in. tap hole for gage
Forge-and-hammer welded shell No. 12	42	2.0	One	...	665	0–1570	0–16,500	890,000	No fracture; test still in progress
Forge-and-hammer welded shell No. 13	42	2.0	One	...	665	0–1570	0–16,500 0–14,650[2]	611,164	Failed in plate away from weld at a longitudinal defect on the inside surface.
Arc-welded shell No. 1	42	2.0	One	80	838	0–1570	0–16,500	5,530	In long. seam near middle of length at junction of base metal and weld metal. Bare welding wire used
Arc-welded shell No. 2	42	2.0	One	80	838	0–1570	0–16,500	267,603	Through slag inclusions in weld
Arc-welded shell No. 3	42	2.0	One	80	838	0–1570	0–16,500	417,381	Failed at ¼-in. tap hole for gage
Arc-welded shell No. 4	42	2.0	Ohe	80	838	0–1570	0–16,500	561,984	Same as for shell No. 3
Arc-welded shell No. 5	42	2.0	One	80	838	0–1570	0–16,500	435,883	Same as for shell No. 3
Arc-welded shell No. 6	42	2.0	One	80	838	0–1570	0–16,500	58,842	Tapped hole for gage located in weld; hole very irregular at inner surface; failure occurred at the tapped hole
Arc-welded shell No. 7	42	2.0	One	80	838	0–1570	0–16,500	1,035,037	No failure; no tapped hole in shell
Arc-welded shell No. 8	42	2.0	One	80	838	0–1570 0–2100	0–16,500 0–22,000	1,995,450 24,400	No failure; no tapped hole in shell No failure—supplementary test of shell No. 8; test still in progress

[1]Given by A.S.M.E. Power Boiler Code except for arc-welded shells where the maximum allowable working pressure is that given by the "Proposed Specifications for Fusion Welding of Drums or Shells for Power Boilers."

[2]Stress across welded seam, which is ¼-in. thicker than plate.

deformed and heated to from 300 to 450 deg. C the material becomes brittle and the fracture has a bluish tinge. Nickel and chromium raise the temperature at which such brittleness takes place. Brittleness is also developed by aging. Cracking from such brittleness is usually through the grain.

Comparative Tests With Oil Fuel and Gas

A most valuable paper on "Comparative Performance of a Large Boiler Using Oil and Natural-Gas Fuels" was presented by F. G. Philo, Superintendent of Steam Generation, Southern California Edison Company. The boiler tested was a 34,160-sq.ft. B. & W. cross-drum, straight-tube type with interdeck superheater, at the Long Beach Station. It is equipped with Peabody combination oil and gas burners, and the furnace is completely surrounded with Bailey water walls. The highest rate at which the boiler was operated on test was 450,751 lb. of steam per hour, which represented 413 per cent of rating. A heat liberation of 27,300 B.t.u. per cu.ft. of furnace volume corresponded to this rating. Efficiency-capacity characteristics were straight lines between 100 per cent and 400 per cent rating with the efficiency when burning oil approximately 4 per cent higher than with gas, because of hydrogen loss.

Superheated steam temperatures were considerably higher when burning gas than when burning oil, due to the lower water-wall heat absorption and the larger flue-gas volume with gas. At 400 per cent rating the total heat absorption of the water-cooled walls was approximately 35 per cent greater with oil than with gas. With oil, the water walls, which accounted for but 3.4 per cent of the total heating surface, absorbed 50 per cent of the total heat at 250 per cent rating and 67 per cent at rating.

At 300 per cent rating when burning oil, the hydrogen loss was 1.44 times the dry-gas loss. At the same rating when burning gas the hydrogen loss was 2.47 times that of the dry-gas loss. Also the total boiler losses with gas fuel were 1.35 times those with oil at 300 per cent rating. The curves show the comparative boiler, air heater and superheater performances with 15 per cent excess air when burning oil and when burning gas.

HOURLY RESULTS OF TESTS AT KALAMAZOO

Test number	1	2	3	4
Number of boilers in use	2	2	2	1
Total lb. coal fired	23,183	17,711	16,888	11,644
Fly ash to stack, lb.	1,951	997	1,498	1,299
Fly ash recovered, lb.	756	624	463	437
Ratio, fly ash to coal, per cent	8.42	5.63	8.87	11.16
Carbon in fly ash, per cent	.....	49.0	35.9	40.4
Carbon in recovered fly ash, per cent	.....	46.2	37.4	46.8
Per cent of fly ash recovered	38.8	46.16	30.90	33.60

FINENESS OF ASH

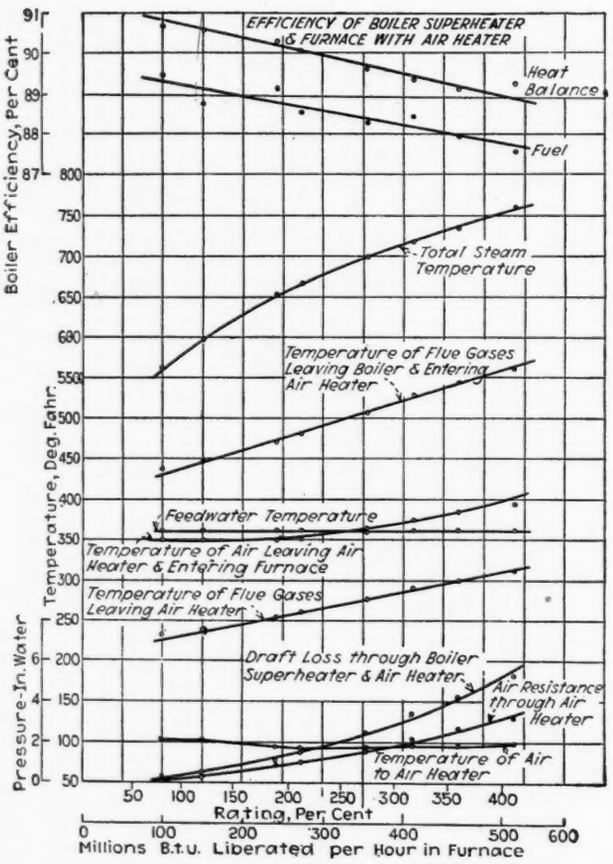
Test No.		Through 200	Through 100	Through 48	Through 28	Over 28
2	Total fly ash	62.7	81.2	95.6	99.6	0.4
	Recovered fly ash	43.6	62.3	91.2	99.6	0.4
3	Total fly ash	60.4	81.5	96.4	99.8	0.2
	Recovered fly ash	60.3	79.9	96.5	99.9	0.1
4	Total fly ash	47.4	62.5	95.1	99.8	0.2
	Recovered fly ash	53.2	71.1	96.0	99.8	0.2

PER CENT CARBON AND FINENESS OF RECOVERED ASH

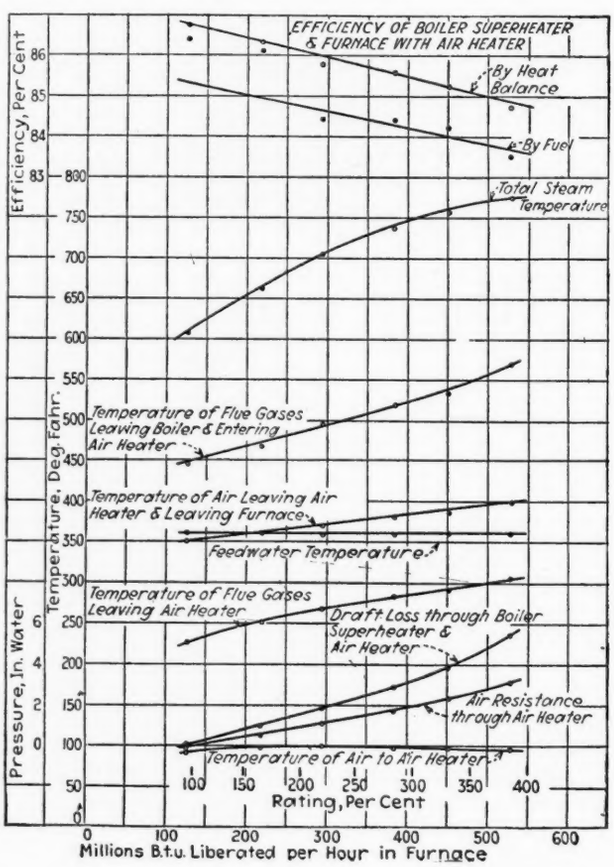
Test No.		Per Cent Carbon	Through 200	Through 100	Through 48	Through 28	Over 28
5	With spray	34.0	61.1	86.6	98.8	99.9	0.1
	Without spray	56.4	27.3	56.2	93.4	99.6	0.1
6	With spray	38.8	73.5	93.0	99.6	99.9	0.1
	Without spray	48.3	48.6	75.4	97.4	99.8	0.2

Recovery of Fly Ash by Stack Sprays

J. W. Mackenzie, mechanical engineer, of the Consumers Power Company, related the experience of that company with the problem of fly ash at the Kalamazoo plant. This, it will be recalled,


EFFICIENCY OF BOILER SUPERHEATER & FURNACE WITH AIR HEATER
Heat Balance
Fuel
Boiler Efficiency, Per Cent
Total Steam Temperature
Temperature of Flue Gases Leaving Boiler & Entering Air Heater
Feedwater Temperature
Temperature of Air Leaving Air Heater & Entering Furnace
Temperature of Flue Gases Leaving Air Heater
Draft Loss through Boiler Superheater & Air Heater
Air Resistance through Air Heater
Temperature of Air to Air Heater
Temperature, Deg. Fahr.
Pressure, In. Water
Rating, Per Cent
Millions B.t.u. Liberated per Hour in Furnace

Boiler, air heater, and superheater performance characteristics with 15 per cent excess air and oil fuel


EFFICIENCY OF BOILER SUPERHEATER & FURNACE WITH AIR HEATER
By Heat Balance
By Fuel
Efficiency, Per Cent
Total Steam Temperature
Temperature of Flue Gases Leaving Boiler & Entering Air Heater
Temperature of Air Leaving Air Heater & Leaving Furnace
Feedwater Temperature
Temperature of Flue Gases Leaving Air Heater
Draft Loss through Boiler Superheater & Air Heater
Air Resistance through Air Heater
Temperature of Air to Air Heater
Temperature, Deg. Fahr.
Pressure, In. Water
Rating, Per Cent
Millions B.t.u. Liberated per Hour in Furnace

Boiler, air heater, and superheater performance characteristics with 15 per cent excess air and gas fuel

was one of the first central stations to employ the unit system of pulverized coal with preheated air, and difficulty was encountered from fly ash. The extent of this trouble was determined by the placing of freshly painted white boards throughout the district. The worst conditions were found to be about three or four city blocks from the plant, disappearing at a radius of about nine blocks. A considerable part of this deposit appeared to be carbon in the form of small particles of coke, which was largely the result of poor pulverization.

It was decided to install a water spray in the stack. At first a group of four spray nozzles was located about 20 ft. above the top of the breeching connection and arranged to form a combined downward spray. While the results were encouraging, the pipe connections soon corroded. Therefore, a single spray nozzle having a capacity of 30 gal. of water per minute at 10 lb. pressure was substituted, with the piping located outside and merely projecting into the stack at the nozzle level. The water and entrained ash were drained from the bottom of the stack into the sump of the ash-sluicing system.

With this arrangement trouble was soon experienced due to flakes of accumulated fine ash coming from the stack and settling in the immediate vicinity of the plant. An investigation showed that an accumulation of this moist ash had collected in a circular band about 3 in. thick inside the stack and finally flaked off and was carried out the top of the stack. The difficulty was overcome by introducing a second, or washing, spray about 15 ft. above the main spray and pointed upward so that the water from it strikes the stack above the ash deposit and washes down the accumulation. The tables on page 956 show the effectiveness of this arrangement as revealed by test.

It will be noted that, under the conditions covered by these tests, the ratio of the fly ash to the total coal varies from about 5½ to 11 per cent of the coal used, and with the spray in operation about 37 per cent of this amount is recovered. The tests show that under normal operation with the stack spray in use there is still about 5 per cent of the total weight of the coal discharged from the stack.

In the discussion of the paper by Mr. Mackenzie, the objection was raised that fine ash is invisible on white paint. It was stated that 35 per cent recovery will not satisfy many communities. Sulphur fumes were mentioned as a problem of growing seriousness that will require extensive research.

Bin System and Unit Mills Compared

A valuable contribution to existing literature and data on the comparative performance of the bin and unit systems of firing pulverized coal was made by A. D. Grunert, efficiency engineer, of the Commonwealth Edison Company, relating long period operating results at Calumet station, Chicago. The result of a 24-month operating test on a B. & W. cross-drum boiler served with the bin system was compared with an 11-month test on the same boiler supplied by the unit system. The operating costs, neglecting fixed charges, were practically identical, as is shown in the table.

COMPARATIVE DISTRIBUTED UNIT COST, BOILER NO. 22, CALUMET STATION BIN SYSTEM VERSUS UNIT SYSTEM

	Dollars per Million B.t.u. Delivered	
	Bin	Unit
Coal and ash handling labor	0.00095	0.00120
Boiler room labor	0.00920[1]	0.00815
Operating labor	0.01015	0.00935
Maintenance, furnace	0.00228	0.00168
Maintenance, boiler and superheater	0.00102	0.00088
Maintenance, feeders and burners	0.00047	0.00406[5]
Maintenance, economizer	0.00126	0.00059
Maintenance, soot blowers	0.0027[2]	0.00042
Maintenance, air preheater		
Maintenance, all fans	0.00214[3]	0.00136[6]
Total maintenance except coal and ash equipment	0.00989	0.00893
Pro-rate share of station maintenance coal and ash equipment	0.00211	0.00233
Maintenance, No. 22 coal- and ash-conveying equipment	0.00197[4]	0.00080
Pro-rate share of maintenance, crusher and breaker	0.00026	0.00318
Maintenance, mill	0.00334	0.01034[7]
Total maintenance coal and ash equipment	0.00768	0.01665
Auxiliary power	0.01140	0.01279
Fuel cost (reduced to a standard basis of $18 per 100,000,000 B.t.u.)	0.21462	0.21496
Total cost (labor, maintenance, auxiliary power, and fuel)	0.25374	0.26258

[1]One fireman and one mill operator for No. 22 bin system alone for nine months.
[2]Additional soot blowers installed (50 per cent of account).
[3]New rotor for induced draft fan (45 per cent of account).
[4]Coal gates on weigh bins for tests (40 per cent of account).
[5]New burners (80 per cent of account).
[6]Repairs on spare induced draft fan rotor (35 per cent of account).
[7]Unusually high maintenance costs due to changes in mill and high operating speed.

A more detailed abstract of this paper will appear in a later number.

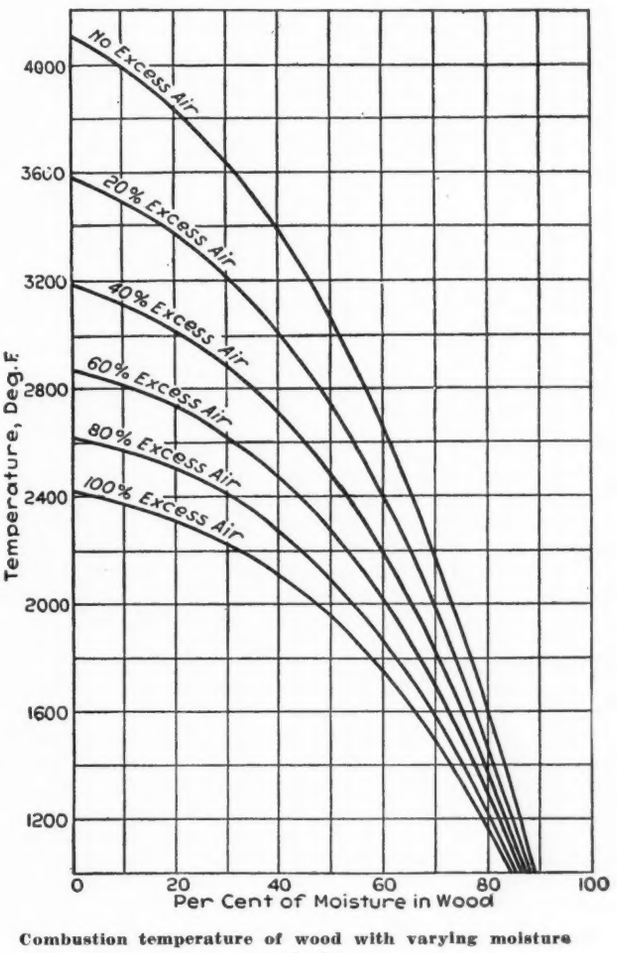
Mr. Grunnert's analysis was highly commended by several in the discussion, but regret was expressed that fixed charges had been omitted from his paper. It was pointed out that operation is only one factor in dollar efficiency. The opinion was expressed that there is little difference in flexibility between the bin and the unit systems in ranges of steam generation between 75,000 and 175,000 lb. per hour. Above or below this range, it was claimed, the bin system is more flexible.

"Boiler Setting for Burning Refuse Wood" was the subject of a thoroughly practical paper by C. S. Gladden, director of power and maintenance of the General Motors Corporation. This included a study of the combustion temperatures of wood under different conditions of moisture content and excess air, as shown in the accompanying curves.

The actual combustion temperature in a boiler furnace is somewhat lower than that indicated by these curves, due to absorption of radiant heat and dissipation of heat through the walls.

Wood refuse available for fuel may be classified by moisture content. "Wet" sawmill refuse ranges from 50 to 70 per cent. The refuse of air-dried lumber used in planing mills and finished lumber operations contains from 15 to 25 per cent moisture, while that of kiln dried lumber usually contains from 5 to 7 per cent.

The average ultimate analysis and



Combustion temperature of wood with varying moisture content

CUBIC FEET OF FURNACE VOLUME SUGGESTED PER SQUARE FOOT OF BOILER HEATING SURFACE

Type of Furnace Wall	Maximum Rate of Heat Liberation B.t.u. per Cu.Ft. per Hr.	Maximum Desired Rate of Steam Generation		
		Normal Rating Cu.Ft.	200 Per Cent of Rating Cu.Ft.	300 Per Cent of Rating Cu.Ft.
Solid standard firebrick walls	11,000	0.435	0.870	.....
Special 60 per cent alumina firebrick walls	14,000	0.342	0.684	1.026
Air-cooled wall construction	17,000	0.282	0.564	0.846
Air-cooled walls, with water-cooling protection	20,000	.....	0.479	0.715

calorific value of dry wood was given as follows:

	Per Cent
Carbon	49.56
Hydrogen	6.11
Nitrogen	0.07
Oxygen	43.83
Ash	0.43

B.t.u. per lb. 8671

The proximate analysis is roughly

	Per Cent
Volatile matter	81.5
Fixed carbon	18.0
Ash	0.5

Because of the high flame temperature when burning dry wood with little excess air the problem of suitable refractories is of great importance. Also, although the ash content is small, its silica and alkaline constituents combine to form a low-temperature slag which readily fluxes with the silica of ordinary brick. Mr. Gladden stated that it has been his experience that the furnace construction requiring the least expenditure in maintenance is the air-cooled wall laid up with standard first quality firebrick having a certain amount of water-cooling protection.

The ignition arches should be designed to promote the maximum evaporation of moisture and volatilization of the wood. If possible, preheated air should be provided.

An agitating grate is better than a chain grate with high-moisture refuse.

After showing various designs of furnaces for burning dry and wet wood and sawmill refuse, Mr. Gladden concluded with a table giving the cubic feet of furnace volume per unit of boiler heating surface.

In the discussion emphasis was placed upon the importance of uniformity and direction of feed. It was pointed out that the proportioning and place of admission of secondary air is a matter of vital importance with waste fuels and that furnace volume is less important than proper distribution of volume.

Max Hecht and D. S. McKinney, both of the Duquesne Light Company, Pittsburgh, presented a paper on "Electrical Conductance Measurements of Water and Steam Applications in Steam Plants." This method is applicable to determining the purity of steam, boiler feed water, and the concentration of boiler and evaporator water.

A hearing was also had on the tentative draft of the "Test Code for Complete Steam Electric Power Plants."

▼ ▼ ▼

New Irish Power Development Will Serve 42 Towns in 1936

BELFAST CORPORATION'S big power station is rapidly being developed as a central power station for the greater portion of northern Ireland. Already a transmission line conveys electricity to Hollywood and Bangor, while a plan for the distribution of electricity through southeast Ulster is outlined in an interim report which J. M. Kennedy has prepared and which has been adopted by the northern Ireland government as a basis for future development.

According to Mr. Kennedy's proposals, existing distributing undertakings in the area would be closed, and a plan of centralized generation and main transmission would be brought into being. The current would be supplied by means of main transmission lines based upon the Harbor power station of the Belfast Corporation. Assuming that the project is carried out, with due regard to economy, by a non-profit-earning public authority—an authority which the Government proposes to establish—Mr. Kennedy states that electricity can be made available at a lower cost than would be possible under the individual development of separate generating stations. The capital cost of the transmission system he estimates at £245,000 ($1,225,000) and that of taking over the existing undertakings of local authorities and private companies at £250,000 ($1,250,000).

The area covered by the report lies to the south of a line drawn from Belfast to Dungannon and east of a line drawn from Dungannon to Newry. It is bounded on the south by the coast and on the east by Strangford Lough, but includes the northeastern corner of County Down from Newtownards to Donaghadee.

Of the nineteen supply undertakings now in existence, Bangor, Holywood, and Lisburn take their power supplies in bulk from Belfast, while the remainder operate local generating stations. The area extends to approximately 304,000 square miles, with a density of just over 250 per square mile. Compared with other projects which are in existence or under construction at the present time in Britain, Mr. Kennedy states that this is a relatively high density of population, and the whole area is one in which, if a fresh start could be made, the supply of electricity could be co-ordinated under a single controlling authority to produce the best and most economical results.

He points out that electrical driving of spinning and weaving factories undoubtedly results in certain economies apart from the cost of current, and declares that there are many cases where a bulk supply of electricity on reasonable terms would enable uneconomical industrial plans to be shut down. He regards it as unlikely that any of the existing electricity concerns in the area concerned (excepting those taking a bulk supply from Belfast) will ever be in a position to offer supplies of current for large industrial purposes on sufficiently attractive terms.

By 1936 Mr. Kennedy estimates that there should be sold to consumers in the 42 towns and villages which would be linked up under the plan some 8,600,000 kw.-hr., representing 66 kw.-hr. per capita in the towns and villages actually supplied, or 28 kw.-hr. per capita in the area as a whole. Figures of the estimated consumption, revenue, and expenditure year by year over a period of twelve years show that with the capitalization of interest and the suspension of sinking fund payments during the first five years of the development the plan should be self-supporting. The estimates of consumption take no account of the potential load, and are therefore on a conservative basis.

Regarding the portion of northern Ireland not dealt with in the report, Mr. Kennedy states that the Antrim Power Company, which has only recently started operations, and purchases electricity in bulk from Larne, intends to carry out in its area similar functions to those outlined in the plan, but has no distribution powers. In the southwest of the country, towards Enniskillen, the density of population appears to be too low to permit of any transmission plan proving remunerative. In the northwest area it will, in his opinion, certainly be desirable to consider whether the transmission line northward from Armagh to Dungannon cannot be extended throughout Newtownstewart via Strabane to Londonderry and return via Limavady to Magherafelt and Dungannon.

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A CORRECTION—In the table at the end of the article, "What's What in Flexible Couplings" in the June 3 number, the statements "Fig. 54—The Medart Company, St. Louis, Mo.," and, "Fig. 55—The Clark Controller Company, Cleveland, Ohio," should have read: "Fig. 54—The Clark Controller Company, Cleveland, Ohio" and "Fig. 55—The Modart Company, St. Louis, Mo."

From Among Readers' Problems

Conducted by
L. H. MORRISON

FUEL PUMP VOLUME PER CYLINDER VOLUME—*What is the ratio of the fuel pump capacity to the cylinder volume of a Diesel engine?* J. C.

Just what this ratio is, in an actual engine, depends upon the desires of the designer, but taking the average air-injection Diesel engine with 70 lb. mean effective pressure per brake-horsepower, the power stroke volume per brake horsepower can be figured from the formula $\frac{P\ L\ A\ N}{33{,}000}$ and if we substitute for $P\ L\ A\ N$ the power stroke volume V, and for P use a value of 70 lb. brake mean effective power, we have a volume per brake-horsepower of 3.3 cu.ft. per min. Engine designers have a pump stroke volume ranging from 1.6 to 2 times the actual volume of oil needed for the engine to develop its full horsepower. On the basis of 1.6 times the volume, and 0.44 lb. of oil per brake-horsepower, the pounds of oil handled per hour, per brake-horsepower, would be 0.7, which would be approximately 21 cu.in. per brake-horsepower per hour, or .33 cu.in. per brake-horsepower per minute. Since the power stroke volume is 3.3 cu.ft., you have a ratio of 1 to 17,280, and this might run up as high as 1 to 25,000.

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SAFE WORKING PRESSURE FOR DISHED HEADS—*What is the formula for determining the safe working pressure for unstayed bumped heads with the pressure on the concave side, and also for pressure on the convex side?* M.J.B.

The formula for thickness required in an unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, is given by the A.S.M.E. boiler code,

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \tfrac{1}{8}$$

where

t = Thichness of plate, in.
P = Maximum allowable working pressure, lb. per sq.in.
TS = Tensile strength, lb. per sq.in.
L = Radius to which the head is dished, in.

Where two radii are used the longer is to be taken as the value for L, and in no case is L to be taken as less than 80 per cent of the diameter of the head. By transposing the formula, the maximum allowable working pressure is found to be

$$P = \frac{(t - \frac{1}{8}) \times 2\ TS}{5.5 \times L}$$

When the dished head has a manhole opening, the formula is to be taken as

$$P = \frac{(t - \frac{1}{4}) \times 2\ TS}{5.5 \times L}$$

and the manhole opening is to be flanged to a depth measured from the outside of not less than three times the thickness of the head. It is also understood that the foregoing formulas shall apply only to cases where the corner radius measured on the concave side of the head is less than $1\frac{1}{2}$ in. or more than 4 in., and between these limits not less than 3 per cent of the value used for L in the formula.

When the pressure is on the convex side, the maximum allowable working pressure is 60 per cent of that for heads of the same dimensions with the pressure on the concave side.

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INCREASING FEED-WATER TEMPERATURE AND BACK PRESSURE—*For the purpose of raising the temperature of the boiler-feed water from 180 to 200 deg. F. in a closed exhaust-steam feed-water heater, and steam used only for the engine, would it pay to increase the present 2 lb. back pressure to 3 lb. on a 22x42-in. non-condensing engine running 90 r.p.m. and developing 250 i.hp. with steam at 100 lb. boiler pressure?* H.A.L.

The horsepower constant of the engine, or power developed per pound mean effective pressure, is

$$\frac{(22 \times 22 \times 0.7854) \times 42 \times 90 \times 2}{12 \times 33{,}000} = 7.257 \text{ i.hp.}$$

per pound mean effective pressure, and each pound additional back pressure would require $\frac{7.257}{250}$ i.hp., or about 2.9 per cent, more steam to be supplied to the engine at the present pressure for developing the present power; that is, there must be 1.029 times as much heat supplied.

Each pound of dry, saturated steam supplied at 100 lb. gage pressure contains 1,188.8 B.t.u. above 32 deg. F., and with the feed water at 180 deg. F. the boiler supplies (1,188.8 + 32) — 180 = 1,040.8 B.t.u. per pound of steam used.

With the feed-water temperature 200 instead of 180 deg. F., for each pound of steam generated the boiler would need to supply 20 B.t.u. less, or 1,048.8 — 20 = 1,020.8 B.t.u. but as 1.029 times as much steam would be required, the boiler would have to furnish $\frac{1{,}020.8}{1{,}040.8} \times 1.029 = 1.009$ times as much heat; that is about 1 per cent more fuel would be required.

Hence under the conditions stated it would not pay to increase the feed-water temperature at the expense of increasing back pressure unless by so doing the exhaust is made available for purposes, like heating, that otherwise would require over 1 per cent as much live steam as now supplied to the engine.

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EFFICIENCY OF AIR COMPRESSOR WHEN HOT—*Why is the efficiency of an air compressor less if it is hot?* T.J.S.

Air at any given pressure occupies a greater volume for an increase of temperature, and the pressure of a given volume is increased for an increase of the temperature. With a hot compressor the volumetric efficiency is less, for the free air as it is drawn into the compressor cylinder has its temperature increased and consequently a smaller quantity, or weight, of air at atmospheric pressure can be admitted per suction stroke.

The work of compression adds heat to the air, and the increase of temperature causes the release pressure to be reached earlier in the stroke, and less heat is abstracted by a hot cylinder than by one that is kept cool. This would be no detriment to efficiency if the compressed air were to be used at the temperature attained in the process of compression.

But, for most practical purposes, the air after leaving the compressor is allowed to stand or become cooled or is intentionally cooled to nearly the temperature at which it was drawn into the compressor. Such cooling is attended by a drop of pressure and a waste of energy; for the higher the discharge temperature above the temperature at which the air is utilized the higher must be the pressure and the greater the amount of work required to compress a given quantity or weight of air to the pressure and temperature at which it is to be used.

Hence, for ordinary uses of compressed air the hotter the compressor the lower its efficiency, because less quantity or weight of air is handled and more power is required to effect a given number of compressions.

PREVIOUS QUESTION

Discussed by Readers

THE QUESTION

WE ARE operating a saw mill and there is a large, constantly burning waste pile. To obviate a large initial payment on steam-heated dry kilns, it has been suggested that a brick fireplace be built with a large number of large air tubes through which warm air might be drawn, then conveyed 80 ft. through heat-insulated pipe by fan to suitable kiln buildings. What cheap method of heat insulation of the pipe could be used? W.S.W.

ASSUMING this to be a problem in low humidity drying, and also assuming that the velocity of air flow in the dry kilns will be vigorous enough to penetrate the interstices of the material drying, the discharge pipe from the warm air tubes may be economically insulated by a return-air duct from the kilns to the tubes, built into a casing around the discharge pipe from the heater tubes.

The relative humidity, the moistening property, of the return air will be higher than the air of the inner pipe. This watery vapor and dust extracted from the material drying forms a part of the atmosphere in this casing and greatly obstructs the passage of radiant heat by the low diathermic value it possesses. The casing material acts as a diathermic screen with a free circulation of air inside and outside.

The heat that is intercepted by the return air is mostly absorbed and but a small part is transmitted through the return-air casing to the air through which the return duct passes.

Price of this type of insulation is not measured in first cost, but in the ample return it pays on the money invested in it. W. J. ANDERSON,
Pipe Shop Foreman,
Brooklyn, N. Y. E. W. Bliss Co.

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I CONCLUDE that it is proposed to build a waste heat air heater to supply hot air to drying kilns instead of steam heating.

It is purely a question of balancing costs when deciding what lagging to adopt. If there is enough waste heat to warm much more air than required, one must balance the cost of a larger air heater and unlagged ducting against lagged ducting and a smaller heater, and I should say the latter scheme is preferable.

The cheapest material would be slag wool held on to the ducting with sheet steel or fine-mesh wire netting, covered with canvas and painted with waterproof compounds. Owing to the probable thickness of slag wool required the substitution of magnesia slabs would facilitate erection, the thickness of the latter being approximately half that required for slag wool on a given radiation.

Before finally stating the cheapest form of lagging, it would be necessary to know the weight and temperature of air passed through the ducting per hour, because definite economic thicknesses for different materials occur with changes in temperature.

The problem may be looked at from this angle, "Why lag the ducting when the hot air is obtained from waste heat?"

One would have maintenance and depreciation charges on the air heater, and the smaller the heater put in the less they would be. T. H. PARDOE.
Wolverhampton, England.

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A CHEAP way to insulate the hot air pipes leading from the burning waste pile of the sawmill would be to build a wood box around the pipe, leaving a space of 3 or 4 in. all around to be filled in with dry wood sawdust.

As cost would seem to be the first consideration in this equipment, the slight expense entailed by this method is apparent, material being obtainable at the mill, and any handy man with saw and hammer can make the box and fill in the sawdust.

This method of pipe insulation is not new or untried. It is often resorted to in Pacific Coast sawmills. I have had a 6-in. steam pipe 150 ft. long, half of it being outside, conveying steam at 125 lb. pressure to a head-saw engine cutting 125,000 ft. of lumber per 8-hr. shift, covered in this manner. Only in this case the pipe was first wrapped tightly with one turn of thin asbestos sheeting before filling in the sawdust.
THOS. MIDDLETON.
Vancouver, B. C.

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I THINK the cheapest way to insulate the pipe would be to use a second jacket around it and fill the space between the two pipes with sand. This could easily be done by first placing the air pipe in position, then making a jacket of galvanized iron or similar sheet metal to fit loosely around it, say, with a space of half an inch between the two pipes. This space should be loosely filled with dry sand. Making the second jacket of short lengths of pipe would facilitate filling. After a wrapping of canvas has been put on the outer jacket it should be aluminum painted.

An even cheaper method would be to use a second jacket made of thin mesh wire netting. Give it a tight wrapping of canvas. Then punch holes in the top of the covering and fill with sand. Then apply a second canvas wrapping and finish as before. W. E. WARNER.
London, England.

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AS THE PLANT is a sawmill, there should be available an abundance of sawdust, and there should also be plenty of clay in the vicinity.

Work up a plastic mass of clay and sawdust and apply gobs of the mixture at intervals along the pipes to a thickness of about half an inch. When dried sufficiently roll on a layer of chicken-wire and fasten it securely. Then apply several coats of the clay-sawdust plaster after the preceding layer has dried. This material is not as efficient as the asbestos coverings, but it has one thing to recommend it—cheapness.
C. O. SANDSTROM.
Los Angeles, Calif.

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I BELIEVE there is no cheaper heat insulating material to be obtained than the mill sawdust or fine shavings. This sawdust could be applied and held to the hot-air ducts in a variety of ways, the cheapest of which would be to make a sufficient number of wooden casings having an inside diameter 5 to 6 in. larger than the outside diameter of the hot-air ducts. These casings could be made in halves and the lower half assembled to the duct and packed quite solidly with sawdust. The upper casing should then be applied and likewise solidly packed with the insulating material through an opening throughout its length, this opening to be closed after the packing operation. The entire casing should be bound with wire or steel hoops. The exterior of the casing should then be given a heavy coat of paint, such as used on boilers or smoke stacks, to make it as nearly watertight and waterproof as possible.
Philadelphia, Pa. C. E. ROBSON.

A Question for Our Readers

WHAT should be a fair efficiency in a natural-gas burning boiler plant when the plant operates at 250 lb. pressure and the feed water is at 210 deg. F. Would it pay to install economizers or air preheaters to raise the efficiency? G.C.R.

Suitable answers from readers will be paid for and published in the July 22 number.

WHAT'S NEW IN PLANT EQUIPMENT

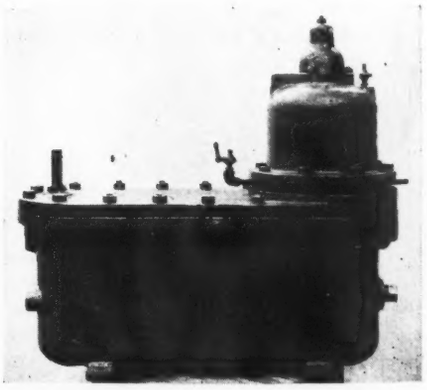
HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING, TRANSMITTING AND APPLYING THE POWER SERVICES

Air-Balanced Flow Proportioner for Corrosive Solutions

IN VARIOUS PROCESSES, as, for example, in the softening of water, accurate proportioning of one fluid to another is essential. Devices in which the primary stream and the secondary stream are each measured by the pressure differential due to flow of the respective streams through an orifice are in use. In some instances, however, the fluid to be controlled is corrosive, for example, sulphuric-acid solution, in which case it is not desirable to have it come into direct contact with the diaphragms or pistons of the balancing mechanism.

To overcome this difficulty the air-balanced proportioner illustrated has been developed by the Cochrane Corporation, Philadelphia, Pa. This proportioner is especially adaptable to feeding sulphuric acid solution into boiler feed water to correct abnormally high causticity.

Referring to the sectional view, it will be seen that the corrosive solution is held at a constant level in a feed tank by a float-regulated valve which controls inflow from a source of higher pressure, while the outflow of the corrosive solution is through an orifice. The pressure acting upon the outflow orifice is determined by the air pressure above the liquid level in the solution tank. This pressure is regulated automatically by a balancing device consisting of three corrugated bellows, all attached to a single movable diaphragm whose position is transmitted to a valve at the top. The surface of the diaphragm contained within the inner pair of



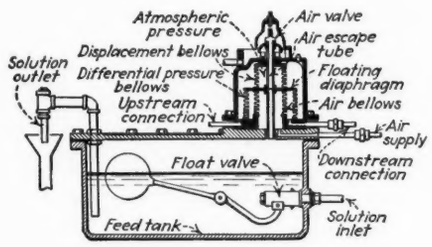
Air-balanced proportioner for chemical solutions

bellows is acted upon beneath by air pressure within the feed tank, while the upper surface is open to the atmosphere. The annular portion of the diaphragm outside of the inner bellows and within the outer bellows is acted upon on its upper surface by the pressure from the upstream side of an orifice in the primary flow pipe and upon its underside by the pressure from the downstream side of the same orifice.

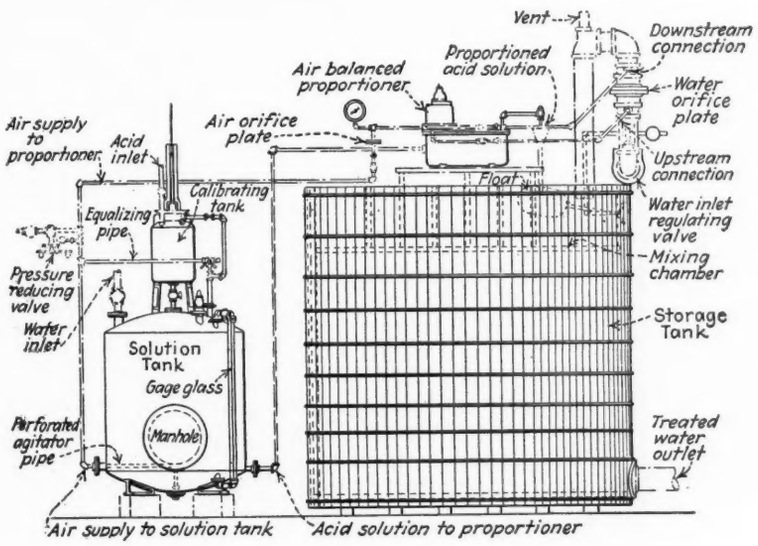
The differential due to the flow of the primary liquid is thus balanced against the pressure within the feed tank. Should the latter be greater in proportion than the differential due to the primary flow, the valve member will rise and allow some of the air to escape. Conversely, should it be too small the valve will close until air pressure in the tank builds up to the proper degree. In actual operation a balance is reached where some air leakage occurs constantly at the proper rate.

Discharge from the feed tank is led through a tunnel and pipe to the mixing apparatus, where air or mechanical agitation is used to insure mixture of the solution with the primary liquid.

The tank from which the acid solution is received may be located below the air-balanced proportioner and the acid lifted up to the latter by admitting pressure from the primary air supply to the solution tank.



Sectional view of proportioner and diagram, showing connections with solution and storage tank



Similarly, the latter may be fitted with a calibrated measuring tank and with air pressure connections so that acids can be charged into the solution tank without releasing the pressure on the latter. The supply for the proportioner may also be obtained from an elevated tank or by means of a constantly running centrifugal pump if desired.

Fixed-Ratio and Infinitely Variable Speed Reducers

THE accompanying illustrations show two types of power transmissions, or speed reducers, which were developed in England and are now being introduced in this country by the Universal Gear Corporation, 327 South La Salle Street, Chicago, Ill. Fig. 1 shows a fixed-ratio unit known as the "Heliocentric," and Fig. 2 the "Revocentric," an infinitely

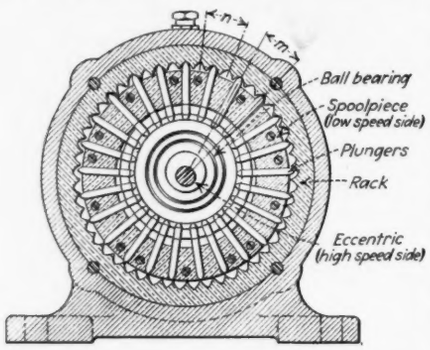


Fig. 1—Cross-section of "Heliocentric" speed reducer

variable speed reducer. The "Heliocentric" unit consists, essentially, of a casing, around the inner periphery of which is an internal gear rack. Inside of this is a spool piece carrying a number of plungers that bear, at their inner ends, upon an eccentric. The eccentric is driven at the high speed of the motor, and the spool piece, connected to the low-speed side, is driven at a reduced speed as the plungers are forced against the rack by the eccentric rotation.

The reducer illustrated has 25 plungers and 49 rack teeth. The angular distance through which the spool piece advances while the eccentric is turning through any given angle equals the difference between the angular distance from one tooth to the second following n, minus the angular distance between plungers m.

Reducers of this type are made for reductions of from 8 to 1 up to 60 to 1, and, by using two or more reducers in series, in ratios as high as 1,000,000 to 1. Sizes to transmit up to 50 hp. are available. These reducers also are built as an integral part of an electric motor.

The "Revocentric" reducer consists of an adjustable-throw eccentric on the input shaft, driving five clutches through toggle joints mounted between two disks on the output shaft.

The means (not shown) for varying the throw of the eccentric is comparatively simple. By a handwheel the inner member of the hollow drive shaft is rotated with respect to the outer member by prongs keyed to the inner shaft that slide in helical slots in the outer. This causes the inner and outer eccentric members of the cam to turn with respect to each other and vary the eccentricity from zero to maximum.

Referring to the illustration, Fig. 2, the eccentric rotates at the input speed. It carries, on a roller bearing, a ring which is practically stationary angularly with respect to the output system, but which oscillates as the eccentric rotates. This ring carries a toggle system pivoted to the ring at point A. The toggle is also pivoted to the output system at point B. The output system remains concentric with the casing. Hence as the oscillating ring is forced outward at point A by the rotation of the eccentric the toggle plate pivots about B, carrying the arm CD outward. This causes the clutch to pivot at D and jam between the inner and outer stationary rings. As point A continues to be forced outward after the clutch has jammed, point C is forced farther from line AD, carrying point B, and hence the

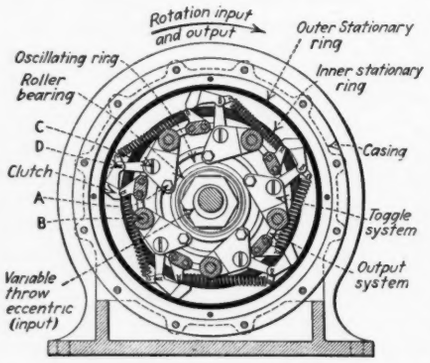
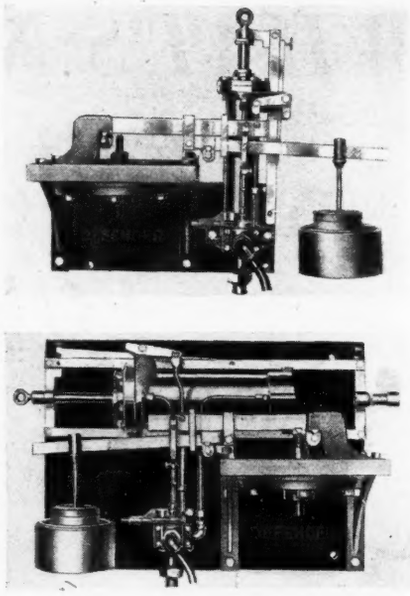


Fig. 2—Clutch mechanism of "Revocentric" variable speed drive

entire output system, forward in a clockwise direction.

This reducer is infinitely variable in output speed from one-thirteenth of the input speed to zero. The speed may be varied while the gear is in motion and under load. It is available in sizes up to 15 horsepower.



Two-lever type regulator with operating cylinders vertical and horizontal

Improved Automatic Damper Regulator

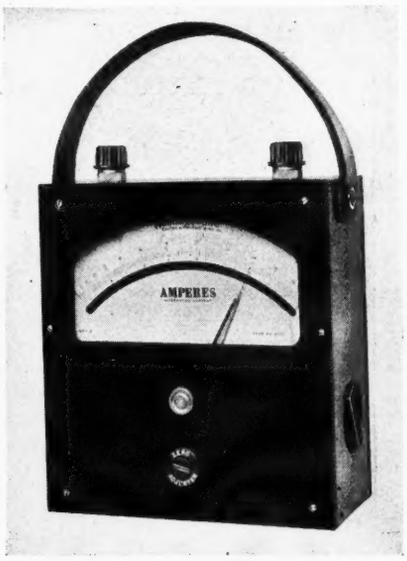
SENSITIVITY combined with small size and light weight are important features of the double-lever (Model DD) damper regulator recently introduced by the Defender Automatic Regulator Co., St. Louis, Mo.

The sensitiveness of the regulator is credited to the unusually small travel of the diaphragm (1/100 of an inch) and of the pilot valve ($\frac{1}{32}$ in.). Fulcrum bearings on the end of the lever above the diaphragm are close together, and the pilot valve is close to the main fulcrum bearings, which tends to increase the power of the diaphragm and reduce the friction.

The unit is designed to function on $\frac{1}{8}$ lb. change in steam pressure and to make a number of uniform stops or steps in closing and opening, according to the steam demand on the boilers. It is particularly suitable for individual boiler control, or as a master control for a battery of boilers, and can be supplied with 2, 3, 4, 5, or 6 in. diameter cylinders with 6, 8, or 10 in. piston travel. With this range of cylinder diameters and piston travel a unit is readily adapted to practically any installation requirements.

Four types of the unit are available, single-pull vertical cylinder (as illustrated in the upper view), double-pull vertical cylinder, double-push-and-pull horizontal cylinder type (as shown in the lower view), and a

low-pressure unit with single-scale beam. The double push-and-pull cylinder types are especially suited to installations where it is desired to operate two or more controls with one regulator. Compensators are provided which can be adjusted so that the regulators will make the full travel of the piston a step at a time on any variation of steam pressure up to 15 pounds.



Portable ammeter for indicating starting, locked-rotor and running current

New Motor-Starting Ammeter

A READILY obtained measurement of the instantaneous starting current of alternating-current and direct-current motors, accomplished heretofore only with an oscillograph, has been made possible through the development of a new ammeter, designated Type PY-5, by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The instrument has a double range, and changeover from one range to the other is accomplished simply by turning a switch on the side of the case.

Such measurements as starting current, locked-rotor current, and running current can be made without disconnecting the instrument from the line. To measure motor-starting current, the instrument is connected in the circuit like any other ammeter, but the reading is taken by the "set-and-try" method. The pointer is set to approximately the right position by means of the manually operated stop, and power is turned on. If the setting proves high or low, the pointer is reset and a second trial made. Where the final adjustment is reached the needle will quiver just a little when the current is turned on, indicating that the maximum starting current is being measured. After the reading is taken, the stop can be returned to zero.

Airplane-Propeller-Type Fan

THE efficiency of the modern airplane propeller has been made available for industrial uses through introduction of a line of propeller-type fans by the American Propeller Company, Inc., 220 Grindall St., Baltimore, Md.

Designated "Aerospot," the new line is put out in three models. Model A is fitted with a 42-in. fan driven by a 2-hp., 3-phase, 60-cycle 1,750-r.p.m., 110- or 220-volt motor with built-in switch. Model B is

Model C propeller-type fan

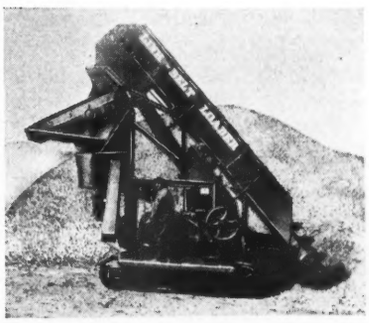
equipped with a 36-in. fan and a 1-hp. motor, and Model C, illustrated, with a 30-in. fan and a $\frac{1}{2}$-hp., single-phase motor.

The propeller is made with a core of white birch, laminated and matched to eliminate vibration; then completely incased in heavy-gage Monel sheathing and hermetically sealed to protect the blades from moisture or excessive heat that might be encountered in service. Bases are of heavy-gage angle iron or piping, and the fans are incased in cages of heavy-gage galvanized wire. Two legs are mounted on casters for easy portability.

High Capacity Crawler Loader

DEVELOPMENT of the new high-capacity crawler bucket loader shown in the accompanying illustration is announced by the Link-Belt Company, of Philadelphia. The new machine will be known as "The Grizzly, 1930 Model." Particular stress is laid on the construction of the self-feeder with which the loader is equipped. This new feeder is of the continuous helical ribbon type, which it has been proved feeds and cleans up uniformly. The action of its self-sharpening spiral and cutting edge serves to cut, dig, and convey material to the elevator buckets in a smooth, uniform stream. The feeder's adjustment is controlled by a handwheel within reach of the operator, who rides with the machine on a side platform built above the crawler unit.

The machine has a rated capacity of $1\frac{3}{4}$ cubic yards per minute, handling run-of-mine coal, coke, etc. The regular power unit includes a 30-hp. gasoline engine or a 20-hp. electric motor for operating the bucket, elevator, feeder, and crawler traveling mechanism. The crawler is wide and long to give stability, and the frames are one-piece steel castings. It is also said to be self-cleaning.



"The Grizzly, 1930 Model" crawler loader with helical ribbon-type feeder

NEWS of the FIELD

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Spot News

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FOLLOWING *approval by the Department of Justice of the recently signed contracts for power to be generated at Boulder Dam, the House Appropriations Committee reported out the second deficiency bill June 11 with an appropriation of $10,660,000 for the commencement of construction on the dam. Early passage of the bill by the House and Senate is expected.*

•

CONSTRUCTION *of a 96,000-kw. steam power plant will be started soon by the Freyn Engineering Company, of Chicago, in conjunction with the erection of an enormous steel mill at Kuznetsky in Soviet Russia. The plant will supply power for the production of 1,000,000 tons of steel annually.*

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WORK *has been started on the laying of the $100,000,000 natural gas pipe line between the Texas oil fields and Chicago, it was announced June 11 by Henry L. Doherty & Company. Deliveries of 24-in., high-pressure pipe and other equipment have already begun. Construction also will start immediately on a number of compressor stations, which will have an ultimate total installation of 100,000 horsepower.*

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AN APPARENT DEADLOCK *has been reached between Senate and House conferees over the disposition of Muscle Shoals. The Senate has passed the Norris resolution providing for government operation while the House measure provides for leasing the properties to private interests. Though Senator Norris proposed a compromise by which the government would operate the power facilities and private manufacturers would lease the nitrate plants, it is highly improbable that any decision will be reached at this session of Congress.*

En Route to Berlin

SS RESOLUTE AT SEA JUNE 11

AMERICAN DELEGATION LOOKS FORWARD TO COMING WORLD POWER CONFERENCE WITH ASSURANCE OF ITS ECONOMIC TECHNICAL AND SOCIOLOGICAL BENEFITS MANY DELEGATES ARE PLANNING SPECIAL INSPECTION TRIPS AFTERWARD WHICH WILL BRING BACK THE MOST ADVANCED EUROPEAN IDEAS FOR APPLICATION TO AMERICAN PRACTICE THUS WILL THE BERLIN MEETING TO WHICH WE ARE SPEEDING BE A BEACON LIGHT TO ENGINEERING PROGRESS

ELY C HUTCHINSON

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Steam Table Experts to Meet in Berlin

Steam table experts of the world will meet again this summer to compare notes and review progress being made toward an international agreement on the thermal properties of steam. The German experts will play host this year, and the conference will take place in Berlin, June 23-26. The United States will be represented by six members of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam as follows: G. A. Orrok, H. N. Davis, H. C. Dickinson, F. G. Keyes, N. S. Osborne, and J. H. Keenan.

The first conference was held last summer in London at the invitation of the British Electrical and Allied Manufacturers' Association. At that time a skeleton table or network of fixed points with tolerances was agreed upon as criteria for judging the accuracy of tables and charts which might be produced giving the thermal properties of steam. During the past year a large amount of such data has been obtained by the various experimenters, and it is expected that the tolerances in the values of the skeleton tables will be reduced at the coming conference.

This investigation is headed up in this country by the A.S.M.E. Special Research Committee under the chairmanship of Alex Dow, past-president of the society. Industry has generously supported the work, which has cost to date approximately $100,000 over the past nine years. It is expected that another $100,000 will be required to complete the committee's program of experimental work at the Massachusetts Institute of Technology and the United States Bureau of Standards.

Power Commission Bill Amended by House

The Couzens bill reorganizing the Federal Power Commission was approved with certain amendments by the House on June 9, despite opposition raised on the grounds that the measure would interfere with the work of the War Department on navigable streams. The Senate, however, disagreed to the House amendments and the bill again went back to conference on June 10.

What is regarded as the most important change made by the House is the addition of the section requiring the new commission to make regular re-

ports to Congress similar to those tendered by the Interstate Commerce Commission. The House also increased the number of commissioners from three to five. The section approved by the Senate giving the President express authority to remove the commissioners for prescribed causes was stricken out. The provision of the Senate bill restricting the commissioners from engaging in other business also was stricken from the measure.

In commenting on the measure, President Hoover expressed his gratification that it had passed both the Senate and the House. He said he looked for early approval of the bill, which he characterized as a "very important administrative step."

Hold Ceremony to Dedicate Flathead Power Site

To dedicate the site of the power plant of the Flathead power project to be built by the Rocky Mountain Power Company, a subsidiary of the Montana Power Company, appropriate ceremonies were held recently at the site on the Flathead River about four miles above Polson, Mont. Frank M. Kerr, vice-president and general manager of the Montana Power Company, with headquarters in Butte, participated in the ceremony as the representative of the power company, and Chiefs Charlo and Koostagah of the Flathead Indians and Chief Michel of the Pend Oreilles, represented the Indian owners of the property.

Preliminary work is to be started at once, according to announcement of Mr. Kerr. According to the terms of the 50-year license recently granted by the Federal Power Commission to the Rocky Mountain Power Company, the company will pay a rental to the Indians of $2,845,000 during the first twenty years. After that the rental will be adjusted for ten-year periods.

Five Ohio Utilities to Form Merger

A joint application was filed with the State Utilities Commission June 10 for authority to consolidate five of the largest power concerns in Ohio with a combined value of about $125,000,000. The companies involved are the Ohio Edison Company, the Northern Ohio Power and Light Company, the Pennsylvania-Ohio Power and Light Company, the Akron Steam Heating Company and the London Light and Power Company. Known as the Ohio-Edison Company, the new merger would have a generating capacity of 435,500 hp.

If the merger is approved $15,000,000 in new capital will be furnished by the Commonwealth and Southern Corporation, which now owns all of the common stock of the companies merging.

WORLD'S HEAVIEST CONVEYOR BELT

Shipped in three rolls weighing 21,000 lb. each, this conveyor belt, the heaviest and thickest ever used, was recently installed in the new screening plant of the Michigan Limestone & Chemical Company. Made by the Robins Conveying Belt Company, it is 54 in. wide, 1¾ in. thick with 16 plies at the side and 14 plies at the center, and handles 1,950 tons per hour

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Russia Purchases Some American Lightning

Russian students of electrical engineering will soon be experimenting with American-made lightning, when the 1,000,000-volt testing set made at the Pittsfield, Mass., works of the General Electric Company is installed at Leningrad. The outfit, half as large as the one installed at Stanford University a few years ago, will be erected in the Electro-Technical Institute at Leningrad. It will be used for general testing purposes and for the study of various high-voltage phenomena.

The equipment, the first built at Pittsfield for a foreign country, was shipped with cores and coils completely immersed in oil, ready for operation upon arrival. Each transformer weighs approximately twenty tons.

Purdue to Have Library of Engineering History

Purdue University is the recipient of a gift of $20,000 from Mrs. W. F. M. Goss for the purpose of establishing at that institution a library of engineering history. Mrs. Goss has also given the university the books which formed the personal library of the late Dr. Goss.

Purdue will be able to build up a collection of important and interesting books on the history of engineering. Through Dean A. A. Potter it is learned that the income from the Goss fund will enable the university to purchase a few rare books and to pay express charges on volumes donated to the historical library. Anyone having books dealing with the history of engineering or engineering books of historical interest which he would like to donate to the new library at Purdue should communicate with A. A. Potter, Dean of Engineering, Purdue University, Lafayette, Ind.

New Jersey Starts Campaign for Smoke Abatement

A program of education, rather than annoyance and prosecution, is to be instituted by officials of Jersey City in abating the smoke nuisance from large industries and railroads, according to an announcement by Mayor Hague June 10 during a conference with representatives of railroad companies and industrial plants. The conference was the result of complaints of citizens in localities where the alleged nuisance has been flagrant.

County Supervisor O'Neill said the Board of Freeholders had decided to establish a Smoke Abatement Commission, to be composed of Dr. Harvey N. Davis, president of Stevens Institute of Technology, and Col. Elliott H. Whitlock. Mr. O'Neill also announced that J. N. Haffer, chairman of the New York and New Jersey Smoke Abatement Board, had volunteered to co-operate.

News of Canada

Progress made on Chute-a-Caron project — New steam plant in operation at Glace Bay — Ruskin development nears final stage

OPERATIONS of the Aluminum Company of Canada at Arvida, Quebec, have attracted wide attention in the last year or two throughout Canada and also in other countries, not only because of the prospective growth of a city of some magnitude founded on a single new Canadian industry, but because of the huge hydro-electric development on the Saguenay River, which is associated with the enterprise. At Chute-a-Caron, an ultimate development of 800,000 to 1,000,000 hp. is planned. Pending delivery of power from Chute-a-Caron, the company is obtaining its supply of electrical energy from the Isle Maligne plant of the Duke-Price Power Company, higher up on the Saguenay, under a 100,000-hp. contract.

The dam at Chute-a-Caron is well under way and the first power from the new development should be forthcoming early in the spring of 1931. It is a two-stage development. The works now under construction will produce about 250,000 hp. When this amount of power will no longer suffice, it is proposed to build a canal or aqueduct to carry the water about two miles further down the Saguenay and release it at tidewater through a power house which will develop about 700,000 horsepower.

THE NEW seaboard power plant of the Dominion Steel & Coal Corporation, at Glace Bay, Nova Scotia, representing an outlay of $1,000,000, has been placed in operation. Situated on the shores of Glace Bay Lake, this ultra-modern steam-electric plant using pulverized coal, has been erected to supply electricity for operation of the company's numerous coal mines throughout this district. In preparation for this event much work has been going on in recent months in the erection of high-tension power lines, including the high-voltage submarine line under Sydney Harbor to supply the workings at Sydney Mines, and in changing over machinery at the mines to meet the new conditions created for efficient operation of the company's properties.

The new seaboard plant is the largest electrical station in eastern Nova Scotia. It is close to the No. 24 colliery and will be capable of generating 55,000,000 kw.-hr. of electrical energy annually, with a generator installation of 7,500 kilovolt-amperes.

CONCRETE is now being poured for the 185-ft. dam at the British Columbia Electric Railway Company's hydro-electric development at Ruskin, on the Stave River. The power plant is beginning to assume its final state, and the entire project is expected to be finished by the end of this year. The Ruskin development will provide 47,000 additional horsepower for Vancouver, though ultimately the company plans to develop 188,000 hp. The penstocks are already in place, and equipment has been installed to hoist the turbines and generators to their respective positions in the power house.

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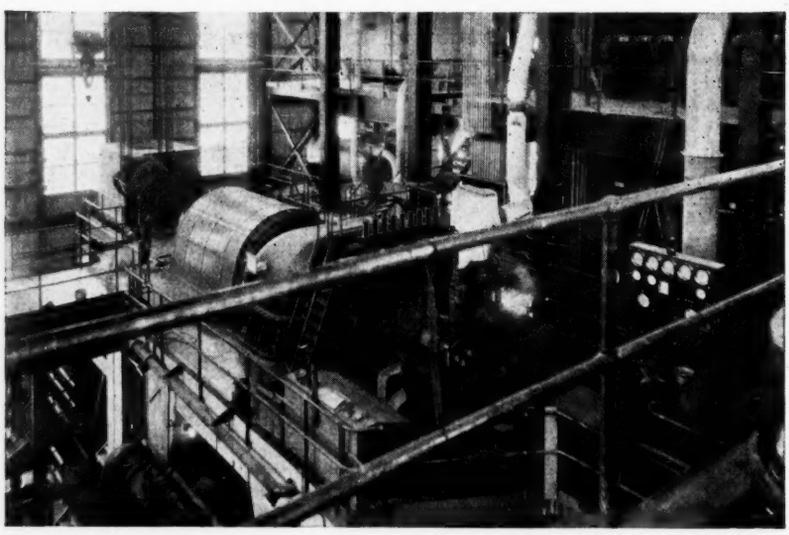
ARIZONA'S NEW CENTRAL STATION



Interior of the new steam-electric plant of the Central Arizona Light & Power Company, near Phoenix, Ariz., showing 24,000-hp. turbine-generator. Completed in nine months at a cost of $2,550,000, this plant is now supplying power to Phoenix and the Salt River Valley

Personals

ELLIOTT H. WHITLOCK, commissioner of smoke inspection for the City of Cleveland, Ohio, has just become the world's first professor of smoke abatement at Stevens Institute of Technology, Hoboken, N. J. In addition, Colonel Whitlock will receive a salary of more than $10,000 a year to lead a national crusade against billion-dollar smoke losses, working through New York and New Jersey city, county and state agencies, with Stevens as his laboratory. He will start an intensive technical survey of smoke conditions in New York City next fall after he finishes his general municipal duties in Cleveland.

O. C. MERRILL, chairman of the American Committee of the World Power Conference: HENRY J. PIERCE, vice-chairman of the committee; and L. F. HARZA, a member of the executive committee of the power division of the American Society of Civil Engineers, have been designated by the State Department to represent the United States on the International Commission on High Dams.

IRVING EDWIN MOULTROP, designer and chief engineer of the Edison Electric Illuminating Company of Boston, Mass., has been awarded the Elliott Cresson medal by the Franklin Institute "in consideration of the engineering skill displayed in the design and construction of the high-pressure installation at the Edgar Station . . ."

GUISEPPE FACCIOLI, widely known electrical engineer, has retired from active participation in the affairs of the General Electric Company because of ill health. He has relinquished his duties as Pittsfield works engineer and associate manager of the Pittsfield works of the company to assume the position of consulting engineer.

MORTIMER E. COOLEY, dean emeritus of the College of Engineering at the University of Michigan and honorary member of the American Society of Mechanical Engineers, was recently made an honorary member of the Franklin Institute, "in recognition of his inspiring guidance in engineering education, and of his enlightened judgment and fearless integrity in the practice of his profession."

FLOYD B. HOBART has been appointed fuel chemist on the staff of Battelle Memorial Institute of Columbus, Ohio. With R. A. SHERMAN, fuel engineer, he will work under the direction of CLYDE E. WILLIAMS, assistant director of the Institute, on research problems in fuels. A graduate of the University of Illinois, Mr. Hobart was formerly on the staff of the Engineering Experiment Station at the University, where he worked with Dr. S. W. PARR on the constitution and carbonization of coal.

Business Notes

L. F. HARZA, Chicago, Ill., announces the incorporation of his engineering service under the name of Harza Engineering Company and removal to new offices at 20 North Wacker Drive. Officers of the company will be: L. F. Harza, president; Erik Floor, vice-president and Jas. S. Bowman, secretary.

M. MONTGOMERY & COMPANY, LTD., Vancouver, B. C., a new electrical engineering company, has just been organized. M. Montgomery, formerly partner in the firm of Bartholomew, Montgomery & Company, Ltd., will be president and managing director of the new firm, which has its offices at 1009 Stock Exchange Building.

RELIANCE ELECTRIC & ENGINEERING COMPANY, Cleveland, Ohio, has sent J. B. Gillham and G. A. Anderson to the Los Angeles and San Francisco offices respectively of the Utilities Equipment Corporation where they will handle the sales of Reliance alternating-current and direct-current motors.

TUBE-TURNS, INC., Louisville, Ky., has announced the appointment of six new distributors: the Grinnell Company, at Charlotte, N. C.; Elbert & Kirkman Company, Inc., of Birmingham, Ala.; the B. Hoffmann Manufacturing Company, of Milwaukee, Wis.; the United Pipe & Supply Company, of Charleston, W. Va.; the Vulcan Copper & Supply Company, of Cincinnati, Ohio; and Hedley & Voisinet of Buffalo, N. Y.

FOOTE BROS. GEAR AND MACHINE COMPANY, Chicago, Ill., has elected Francis A. Emmons vice-president in charge of sales and advertising. Mr. Emmons was formerly sales manager of the company.

AMERICAN DISTRICT STEAM COMPANY, North Tonawanda, N. Y., announces the appointment of Morton McI. Dukehart & Company as its Baltimore district sales representative.

ELEVATOR SUPPLIES COMPANY, Hoboken, N. J., announces the election of Frank N. Smith, president; Emil Ibach, vice-president; and Walter M. Brent, secretary and treasurer. The new operating head, Mr. Smith, was previously connected with the Southwark Foundry & Machine Company.

SQUARE D COMPANY, Detroit, Mich., has merged with the Diamond Electrical Manufacturing Company of Los Angeles, Calif. Under the new merger the Square D Company will be controlled by the same executive personnel, with the addition of Vernon Brown and J. H. Pengilly of Los Angeles as vice-presidents.

THE SUPERHEATER COMPANY, New York City, has moved its offices from 17 East 42d St. to 60 East 42d St., New York City.

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COMING CONVENTIONS

American Institute of Electrical Engineers. Annual summer convention at Toronto, Canada, June 23-27. Secretary, F. L. Hutchinson, 33 West 39th St., New York City.

American Society of Heating & Ventilating Engineers. Annual summer meeting at the Curtis Hotel, Minneapolis, Minn., June 24-27. Secretary, A. V. Hutchinson, 51 Madison Ave., New York City.

American Society for Testing Materials. Annual meeting at Haddon Hall, Atlantic City, N. J., June 23-27. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

National Association of Power Engineers. Annual convention and exhibition of power machinery at the Cleveland Auditorium, Cleveland, Ohio, Sept. 8-13. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago, Ill.

National Association of Practical Refrigerating Engineers. Annual convention and exhibition at the Hotel Peabody, Memphis, Tenn., Nov. 11-14. Secretary, Edward H. Fox, 5707 West Lake St., Chicago, Ill.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Chattanooga, Tenn., June 17-19. Secretary, C. O. Myers, 14 Commercial National Bank Bldg., Columbus, Ohio.

Smoke Prevention Association. Annual convention at the Hotel Robert Treat, Newark, N. J., June 24-27.

Universal Craftsmen Council of Engineers. Annual convention at the Hotel Kimball, Springfield, Mass., Aug. 5-8. Secretary, T. H. Jones, 33 Linden Ave., Cherrydale, Va.

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Trade Catalogs

COOLING SYSTEMS—In a 37-page booklet containing photographs and diagrams, the C. H. Wheeler Manufacturing Company, Philadelphia, Pa., describes water cooling tower installations adapted to various conditions and requirements.

PUMPS—The Chicago Pump Company, 2336 Wolfram St., Chicago, Ill., announces a new bulletin on pneumatic water supply systems. This is No. 111 and features the "Vibrestor" hose connections, "Vibrestor" sub-base and the "Shokarestor." Architects, engineers and contractors interested in pneumatic water systems should find this booklet useful.

AUTOMATIC GAS SYSTEM—In a booklet entitled "The Improved Kemp Automatic Gas System," the C. M. Kemp Manufacturing Company, Baltimore, Md., features the industrial efficiency of the age as exemplified by Kemp.

CENTRIFUGE—The purification of fuel and lubricating oils by the Sharples Super Centrifuge is the subject of a new catalog published by the Sharples Specialty Company, 23rd and Westmorland Sts., Philadelphia, Pa. This 28-page booklet, illustrated with photographs and diagrams, discusses oil purification for Diesels on both land and sea.

INDUSTRIAL MARKETING—A booklet giving a brief but frank discussion of the problems of the industrial advertiser, has recently been circulated by Edwin Bird Wilson, Inc., 9 Hanover St., New York, N. Y.

GEARS—Two folders on gears have recently been distributed by the General Electric Company, Schenectady, N. Y., GEA 1236 on Fabroil gears and GEA 1242 on Textolite gears.

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Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Navy Standard...	New York.....	$2.10 @$2.30
Kanawha.....	Columbus.....	1.35 @ 1.60
Smokeless.....	Cincinnati.....	1.90 @ 2.00
Smokeless.....	Chicago.....	2.00 @ 2.25
S. E. Kentucky...	Chicago.....	1.35 @ 1.60
Steam.....	Pittsburgh.....	1.50 @ 1.60
Gas Slack.....	Pittsburgh.....	.90 @ 1.10
Big Seam.....	Birmingham....	1.50 @ 1.75
Anthracite (Gross Tons)	At Mine, for Shipment to	Price per Ton
Buckwheat.....	New York.....	$3.00
Barley.....	New York.....	1.25 @ 1.50

FUEL OIL

New York—June 12, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75@5.25c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6@6.25c. per gal.

St. Louis—June 5, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.470 per bbl., or 42 gal.; 26@28 deg., $1.545 per bbl.; 28@30 deg., $1.620 per bbl.; 30@32 deg. $1.695 per bbl.; 32@36 deg., gas oil, 4.151c. per gal.; 37@40 deg., distillate, 4.98c. per gal.

Pittsburgh—June 11, f.o.b. local refinery, 30@34 deg., fuel oil, 3.625c.@3.75c. per gal.; 36@40 deg., 3.5c.@4.25c.

Philadelphia — June 3, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 18 deg. plus, $1.475@$1.525 per bbl.; 23@27 deg., $2.00@$2.05 per bbl.

Cincinnati — June 10, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5.25c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.75c. per gal.

Chicago—June 3, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 75@80c. per bbl.; 26@30 deg., 85@90c. per bbl.; 30@32 deg., $1.00@$1.05 per bbl.

Boston—June 9, tank-car lots, f.o.b., 12@14 deg., Baumé, 3.32c. per gal.; 28@32 deg., 5c. per gal.

Dallas—June 7, f.o.b. local refinery 26@30 deg., $1.25 per bbl. or 42 gallons.

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Conn., Hartford—Hartford Electric Light Co., 266 Pearl St., awarded contract for outdoor substation, turbine, electric bay and mercury boiler plant extension at South Meadows, to Stone & Webster Inc., 24 Federal St., Boston, Mass. Estimated cost $300,000.

Conn., Mansfield — State Bd. of Finance, Hartford, received lowest bid for the construction of dormitories, power house and laundry at Mansfield State Training school here, from Manchester Construction Co., Manchester. $228,916.

Conn., New London — City will soon award contract for extensions and improvements to waterworks including reservoir, pump house, pumps, mains, etc. Estimated cost $80,000. G. E. Watters, City Hall, is engineer.

Ill., Springfield—City awarded contract for addition to boiler house in connection with proposed power plant improvements to Alzine Construction Co., Springfield. $64,960.

Ind., Howell—Louisville & Nashville R.R., Louisville, awarded contract for the construction of a power plant here to Platoff Bush, 122 West Liberty St., Louisville. Estimated cost $40,000.

Kan., Wichita—Kansas Gas & Electric Co., c/o J. H. LaGrant, Purch. Agt., will build a 3 story, 154 x 154 ft. service building, etc., at Central Ave. and Platt St. Estimated cost $325,000. Work will be done by separate contracts under the supervision of Phoenix Utility Co., 315 Sedgwick Bldg.

Md., Baltimore—City received lowest bid for the construction of a 46 x 129 ft. pumping station at Druid Hill Park from DeCou & Chidlaw, 857 North Eutaw St. $127,749.

Mass., Newton (br. Boston)—Dept. of Public Buildings, awarded contract for alterations to boiler plant at high school, Newtonville, to John MacDonald Construction Co., 250 Stuart St., Boston, $48,323.

Mich., Allegan — City awarded contract for the construction of a power plant and dam, 120 ft. with concrete spillway and retaining wall, 246 ft. long to develop 3,500 hp. on the Kalamazoo River, to Hay, Weaver Co., South Bend, Ind., $189,061.

Mich., Northville — Bd. of Health, H. F. Vaughan, 1300 Beaubien St., Detroit, will soon award contract for a 2 story addition to sanitarium including power house, etc., here. Estimated cost $200,000.

Minn., Albert Lea—City, R. Anderson, Clk., plans the construction of a 3 story, 75 x 150 ft. central heating plant and gymnasium at school. Estimated cost $150,000. Hamilton, Fellows & Nedved, 814 Tower Bldg., Chicago, Ill., and LeRoy Gaarder, Albert Lea, is associate architect.

Miss., Oxford—Mississippi Building Commission, W. C. Trotter, Secy., State Capitol Bldg., Jackson, will receive bids until June 18, for the construction of a power house, heating plant at University of Mississippi here.

Neb., Omaha — Douglas County, c/o G. Berger, Clk., received lowest bid for the construction of a 50 x 142 ft. power house on Maple St. from R. Butke, 527 Paxton Blk., $38,300.

Nev., Reno—City, J. B. Reese, Clk., will receive bids until June 23, for the construction of a sewage treatment plant, pumping station, etc. C. C. Kennedy, Call Bldg., San Francisco, Calif., is engineer.

N. J., Camden—Public Service Electric & Gas Co., 80 Park Pl., Newark, plans the construction of a switching station here. Estimated cost $150,000. Private plans.

N. J., East Orange—M. A. Wolf, 845 Broad St., Newark, Archt., will soon award contract for the construction of a 10 story apartment building, including steam heating and refrigeration systems, boilers, elevators, etc., on South Munn Ave. for Okin & Isaacs, 24 Branford Pl., Newark. Estimated cost $600,000.

N. J., Hackettstown—F. W. Wentworth, 140 Market St., Paterson, Archt., will receive bids about July 1 for the construction of a 1 story, 30 x 60 ft. boiler house on Church St., here, for Centenary Collegiate Institute, Church St. Estimated cost $40,000.

N. J., Hillsdale — Dept. of Institutions & Agencies, State House Annex, Trenton, awarded contract for boiler settings to Boyd & Fletcher, Trenton, and smoke breeching to Connery & Co., Second St., Philadelphia, Pa., at Hillsdale Hospital here. Estimated cost $25,000.

N. J., Jersey City — Mongiello Bros., 625 Communipaw Ave., is having preliminary plans prepared for the construction of a 100 x 100 ft. ice plant including ice machine, tank, storage building, etc. Estimated cost $40,000. H. H. Ziegler, 26 Journal Sq., is architect.

N. J., Jersey City—Springarn Realty Co., J. Springarn, Pres., 591 Summitt Ave., awarded contract for a 9 story office and stores building at Newark and Oakland Aves., to J. Mitchell, Inc., 24 Journal Sq. Estimated cost $750,000. Steam heating system, etc., will be installed.

N. Y., Brooklyn—Long Island College Hospital, is having sketches made for the construction of a 45 x 100 ft. boiler room and power plant at Pacific and Henry Sts. Estimated cost to exceed $40,000. W. Higginson, 101 Park Ave., is architect.

N. Y., New York—National City Bank, 55 Wall St., plans alterations including boiler room, safe deposit vaults, etc., at 2861 Broadway. Estimated cost to exceed $75,000. A. J. Alexander, 52 Wall St., is architect.

N. Y., New York — New York Polyclinic Medical School and Hospital, 341 West 50th St., awarded contract for the construction of a boiler room, smoke breaching equipment, etc., to F. T. Ley, 578 Madison Ave. Estimated cost to exceed $150,000.

O., Cleveland—City awarded contract for a 1 story, 67 x 74 and 23 x 23 ft. addition to boiler house on Warrensville Farm to W. J. Schirmer Co., 1720 Euclid Ave. Estimated cost $80,000.

Okla., Shindler—City is having preliminary plans prepared for the construction of a municipal electric power plant. Estimated cost $50,000. Engineer not announced.

Okla., Stillwell—City, W. H. Martin, Mayor, awarded contract for the installation of power plant, including two 216 hp. Diesel engines, complete with switchboard and all necessary accessories to J. F. Pritchard & Co., 528 Dwight Bldg., Kansas City, Mo. Estimated cost $75,000.

Ore., Hood River—City voted $50,000 bonds for the construction of an electric light plant including 75 kw. power plant, etc. Stevens & Koon, Spalding Bldg., Portland, are engineers.

Texas—Cameron County Navigation Dist. 15, Harlingen, voted $1,500,000 bonds for irrigation project including pumping plant, distribution system, etc. W. E. Anderson, San Benito, is engineer.

Wash., Tacoma — Bd. of Contracts and Awards, awarded contract for the superstructure of Cushman power house No. 2 near Potlatch in Mason County, to J. E. Bonnell & Son, 760 Commerce St. $161,000.

Wis., Milwaukee—M. Tullgren & Sons Co., 9 Waverly Pl., will receive bids until June 16 for a 6 story, 138 x 160 ft. apartment building including steam heating and refrigeration systems, elevators, etc., on Oaklnad St., for Armory Realty Co., 196 West Water St Estimated cost $500,000.

Equipment Wanted

Boilers—Washington, D. C.—U. S. Veteran's Bureau, will receive bids until June 24, for the removal of six and installation of three new boilers and mechanical stokers and steam jet ash conveyors in Veteran's Bureau.

Boilers Settings, Coal and Ash Conveyors, etc.—Cleveland, O.—City will soon receive bids for a radial brick chimney, 150 ft. high, 7 ft. inside, with boiler settings, coal and ash conveyor, larries, hopper, stoker, force draft fan and truck scale.

Boilers, Stokers, etc.—Skillman, N. J.—Dept. of Institutions & Agencies, State Office Bldg., Trenton, N. J., will receive bids until June 20 for boilers, stokers, breeching, boiler settings, ash and coal handling equipment, conduits, etc., for State College for Epileptics. $25,000.

Compressor, etc.—Beaver, Utah—American Smelting & Refinery Co., A. H. Means, Mgr., McCormick Bldg., Salt Lake City, plans to purchase a 370 ft. compressor, electric hoist, head frame and foundations at Frisco-Lulu mine in Beaver county.

Engines—Washington, D. C.—A. L. Flint, General Purchasing Officer of the Panama Canal, will receive bids until July 7 for two 350 hp. vertical reversing Diesel engines with complete installations for ferry-boat drive.

Pump—Modesto, Calif.—H. E. Gragg, City Clk., will receive bids until June 25, for furnishing and installing one Duplex sewage sludge pump, etc. for proposed sewage treatment work.

Pump and Motor—Chickasha, Okla.—City is in the market for a 1,000 g.p.m. booster pump and motor for waterworks.

Pumping Unit—Oakland, Calif.—East Bay Municipal Utility Dist., will receive bids until June 25 for a second 12,000,000 g.p.d. pumping unit and equipment for Lafayette pumping station, Modelumne River project .

Pumps, Trenton, [illegible] Purchasing Agt., E. J. Quigley, [illegible] will receive bids until June [illegible] centr[illegible]l pumps $5,000.

Pumps—To[illegible] Monte [illegible]ment Co., 808 Maveric[illegible] San Anton[illegible] A. Taylor, Pres., is re[illegible]oids for two electrical pumps, etc., in c[illegible]ion with waterworks.

Industrial Projects

Calif., Compton—Gregg Steel Products Co., awarded contract for the construction of a 1 story, 50 x 80 ft. factory and shops to H. K. Homer, 401 East Los Angeles St., Long Beach.

Calif., Pittsburg — Stockton Fire Brick Co., Russ Bldg., San Francisco, is having plans prepared for the construction of first unit of refractories plant here. Estimated cost $500,000. Private plans. Machinery and equipment including conveyors, etc. will be installed.

Calif., Richmond—A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Archt., will receive bids until June 23 for the construction of a 1 and 2 story automobile assembly plant for Ford Motor Co., Dearborn, Mich. Electric motors and assembly plant equipment will be installed.

Ind., Fort Wayne — International Harvester Co., awarded contract for the construction of a 60 x 100 ft. factory on Bueter Rd. to Indian Engineering & Construction Co. Estimated cost $50,000.

Ky., Louisville—Gulf Refining Co., 7th and Mix Sts., is having preliminary plans prepared for the construction of a warehouse, including unloading docks, loading racks and pumping station. Estimated cost $200,000.

Md., Baltimore—Hinde & Dauch Paper Co., Sandusky, O., awarded contract for a 1 story, 240 x 480 ft. paper plant at Biddle St. and Lone's Lane to Otto Randolph Inc., 53 West Jackson Blvd., Chicago, Ill. $400,000.

Mich., Bay City—Aetna Portland Cement Co., awarded contract for the construction of a 1 story cement storage plant including four silos, 30 ft. in diameter and 80 ft. high with necessary handling and conveying equipment to MacDonald Engineering Co., 53 West Jackson Blvd., Chicago, Ill. Estimated cost $75,000.

Minn., Cloquet—Northwest Paper Co., H. N. Hornby, Pres., awarded contract for a 1 story, 125 x 724 ft. addition to paper mill including machine, heater, finishing and pulp storage rooms to J. Leck Co., 211 South 11th St., Minneapolis. Estimated cost $350,000.

N. J., Jersey City — B. Singer, 921 Bergen Ave., Archt., will receive bids about July 1, for the construction of a 2 story, 45 x 140 ft. factory on Crawford St. for Jersey City Ladder Co. Inc., 677 Montgomery St. Estimated cost $40,000.

N. J., Newark—United Color & Pigment Co., Evergreen Ave., awarded contract for a 3 story, 50 x 105 ft. paint factory at 158 Mt. Olivet Ave. to Adams-Faber Co., 247 Lorraine Ave., Upper Montclair. Estimated cost $45,000.

N. J., Nutley — Hoffmann La Roche, Inc., Kingsland Rd., awarded contract for a 1 and 5 story, 75 x 108 and 35 x 65 ft. chemical plant on Kingsland Rd., to J. W. Ferguson Co., 152 Market St., Paterson. Estimated cost $65,000.

Pa., Erie—Erie Enameling Co., W. Spence, West 20th St., awarded contract for a 1 story, 60 x 120 ft. plant to E. E. Austin & Son, 20th and Reed Sts.

Pa., Pittsburgh—Equitable Meter & Mfg. Co., 400 Lexington Ave., awarded contract for a 1 story, 43 x 120 and 60 x 320 ft. additions to plant to J. F. Haldeman, Whitfield Pl.

Tenn., Murfreesboro—Tennessee Gas Co., Murfreesboro, subsidiary of Utilities Gas & Electric Co., 22 West Monroe St., Chicago, Ill., plans the construction of a gas manufacturing plant here. Work will be done by owner's forces.

W. Va., Moundsville — Fostoria Glass Co., awarded contract for the construction of a 4 story, 90 x 140 ft. factory to C. Shimp, Wheeling. Estimated cost $150,000.

Ont., Welland—Page Hersey Tubes Ltd. 100 Church St., Toronto, will soon receive bids for the construction of a 1 story, 75 x 800 ft. tube mill here. Estimated cost $2,000,000.

Mexico, Nuevo Laredo—Swift & Co., c/o G. Getz, Robert E. Lee Hotel, Laredo, Tex., will soon award contract for the construction of a refinery plant including can making department, boiler and engine rooms, etc. here. Estimated cost $100,000. Private plans. Plant will turn out by-products from fats, etc.